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Public Health Service
Washington, D. C.

June 1964

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I.—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Early indications of possible fission product activity fluctuations in various phases of the environment are detectable by continuous surveillance of gross beta activity in air and precipitation. This form of surveillance does not provide sufficient information for assessing human exposure due to fallout, but it forms a basis for an alerting system and is useful in determining when and where to conduct more intensive monitoring of radioactivity in food, milk, and water.

Gross beta concentrations in air are presented in reports from the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican National Commission of Nuclear Energy, and the Pan American Health Organization. December 1963 data from three networks were combined and are presented graphically by means of isograms on a map of North America (figure 6).

1. Radiation Surveillance Network, December 1963

Division of Radiological Health, Public Health Service

The Radiation Surveillance Network (RSN) is made up of 73 sampling stations distributed throughout the United States (see figure 1). Most of these stations are operated by State health department personnel.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and measured using a thin-window, gas-flow proportional counter, calibrated with a 38,700 pc Sr^{90}-Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula[2] (*1*). The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The December 1963 fission-product beta concentrations in surface air (extrapolated to the

---

[1] The Sr^{90}-Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T=1$.

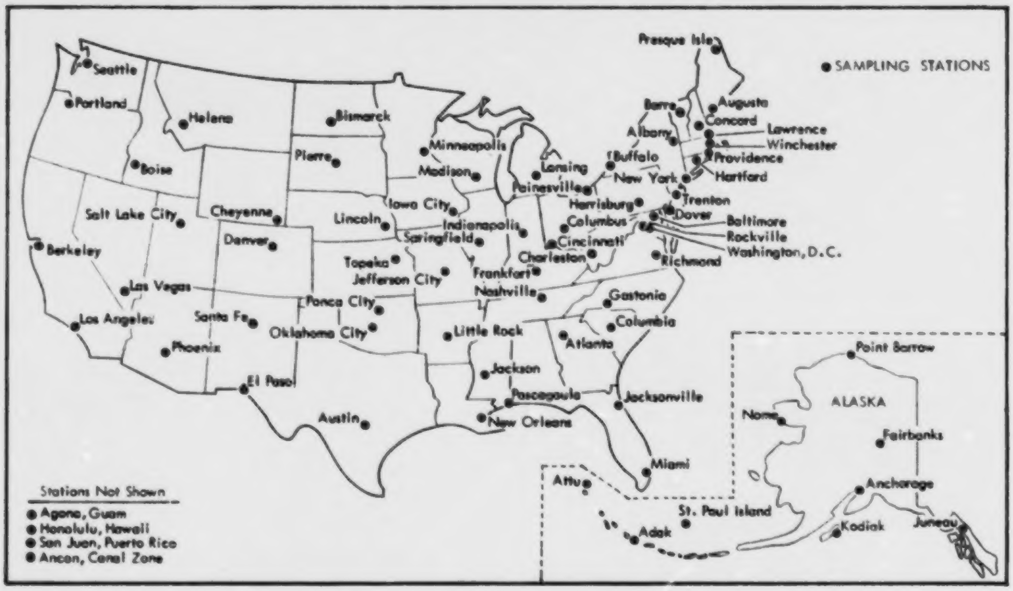
Seattle
Portland
Helena
Boise
Bismarck
Pierre
Minneapolis
Madison
Salt Lake City
Cheyenne
Denver
Lincoln
Iowa City
Indianapolis
Springfield
Berkeley
Topeka
Jefferson City
Frankfort
Nashville
Las Vegas
Ponca City
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Phoenix
Jackson
El Paso
Austin
Pascagoula
New Orleans
Presque Isle
● SAMPLING STATIONS
Barre
Augusta
Concord
Albany
Lawrence
Winchester
Buffalo
Providence
Lansing
New York
Hartford
Painesville
Trenton
Harrisburg
Dover
Columbus
Baltimore
Rockville
Cincinnati
Washington, D.C.
Charleston
Richmond
Gastonia
Columbia
Atlanta
Jacksonville
Miami
Point Barrow
ALASKA
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Kodiak
Juneau
Adak
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, DECEMBER 1963

time of collection) are given in table 1. RSN data along with Canadian and Mexican air data are represented by isograms in figure 6.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, C, is determined by:

$$C = \frac{\Sigma D}{\Sigma P} \times 1000$$

The December 1963 average concentrations and total depositions are given in table 2.

Profiles

The profiles of the monthly average fission product beta activity of airborne particulates for each RSN station, covering the period of time from the formation of the network in 1956 to the end of 1960, were published in the July 1961 issue of *RHD*. In recent issues, several profiles have been updated each month. The last column of table 1 gives the issue of *RHD* having the most recent profile for each station. Eight profiles are updated through December 1963 in figure 2.

TABLE 1.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, DECEMBER 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]	Last profile in *RHD*
Alaska:	Adak	26	0.91	<0.10	0.46	Nov 63
	Anchorage	26	1.4	<0.10	0.51	Jul 63
	Attu	31	0.95	<0.10	0.49	Dec 63
	Fairbanks	12	0.83	0.15	0.53	Aug 63
	Juneau	23	1.5	0.14	0.46	Sep 63
	Kodiak	21	1.1	<0.10	0.28	Oct 63
	Nome	17	0.79	<0.10	0.39	Feb 64
	Point Barrow	30	0.70	0.14	0.39	Jan 64
	St. Paul Island	26	1.0	0.21	0.52	Mar 64
Ariz:	Phoenix	28	3.3	0.75	1.6	Sep 63
Ark:	Little Rock	29	1.8	0.27	1.3	Sep 63
Calif:	Berkeley	20	1.4	0.28	0.70	Oct 63
	Los Angeles	21	2.6	0.72	1.6	Feb 64
C. Zone:	Ancon	15	0.59	0.17	0.33	Apr 64
Colo:	Denver	22	2.7	0.61	1.3	Nov 63
Conn:	Hartford	25	1.1	0.19	0.74	Oct 63
Del:	Dover	18	0.92	0.20	0.62	Aug 63
D. C:	Washington	31	1.2	0.13	0.67	Apr 64
Fla:	Jacksonville	25	1.9	0.47	1.3	Oct 63
	Miami	26	4.4	0.29	1.7	Feb 64
Ga:	Atlanta	18	1.1	0.30	0.67	Jul 63
Guam:	Agana	28	1.1	<0.10	0.41	Apr 64
Hawaii:	Honolulu	25	2.2	0.16	0.60	Feb 64
Idaho:	Boise	24	1.6	0.20	0.86	Dec 63
Ill:	Springfield	16	1.2	0.32	0.64	Mar 64
Ind:	Indianapolis	26	1.3	0.34	0.72	Jul 63
Iowa:	Iowa City	26	1.4	0.30	0.66	Jan 64
Kans:	Topeka	24	1.8	0.36	0.89	Jul 63
Ky:	Frankfort	30	1.4	0.30	0.79	Feb 64
La:	New Orleans	25	1.8	<0.10	1.1	Mar 64
Maine:	Augusta	30	1.6	0.28	0.93	Mar 64
	Presque Isle	27	1.0	0.18	0.66	Nov 63
Md:	Baltimore	21	1.1	0.15	0.61	Nov 63
	Rockville	16	1.5	0.23	1.0	Mar 64
Mass:	Lawrence	25	1.5	0.28	0.99	Aug 63
	Winchester	23	1.4	0.22	0.80	Apr 64
Mich:	Lansing	29	1.7	0.30	0.91	Feb 64
Minn:	Minneapolis	25	1.1	0.26	0.61	Mar 64
Miss:	Jackson	23	1.6	<0.10	0.90	Apr 64
	Pascagoula	11	2.1	<0.10	1.2	Dec 63
Mo:	Jefferson City	25	1.4	0.37	0.82	Nov 63
Mont:	Helena	24	2.0	0.30	1.0	Nov 63
Nebr:	Lincoln	5	0.67	0.44	0.57	Apr 64
Nev:	Las Vegas	25	4.2	0.70	2.3	Jul 63
N.H:	Concord	19	1.9	0.26	1.1	Feb 64
N.J:	Trenton	24	1.8	0.11	0.71	Apr 64
N. Mex:	Santa Fe	25	2.8	0.78	0.71	Dec 63
N.Y.	Albany	20	1.9	0.14	0.85	Jul 63
	Buffalo	6	—	—	—	Nov 63
	New York	21	1.1	0.16	0.72	Dec 63
N.C:	Gastonia	25	1.8	0.35	0.98	Jan 64
N. Dak:	Bismarck	22	1.5	0.33	0.78	Feb 64
Ohio:	Cincinnati	20	0.88	<0.10	0.57	Aug 63
	Columbus	29	1.4	0.26	0.70	Apr 64
	Painesville	31	2.0	0.36	0.96	Oct 63
Okla:	Oklahoma City	29	1.6	0.33	0.99	Apr 64
	Ponca City	22	0.95	0.31	0.67	Oct 63
Ore:	Portland	26	2.8	0.33	1.2	Oct 63
Pa:	Harrisburg	23	1.2	<0.10	0.64	Jan 64
P.R:	San Juan	25	0.81	0.12	0.37	Mar 64
R.I:	Providence	28	1.2	0.29	0.80	Jan 64
S.C:	Columbia	22	1.4	<0.10	0.69	Dec 63
S. Dak:	Pierre	26	1.3	0.31	0.70	Sep 63
Tenn:	Nashville	31	1.9	0.30	0.93	Jan 64
Tex:	Austin	23	2.6	0.54	1.4	Aug 63
	El Paso	23	2.7	0.62	1.5	Jan 64
Utah:	Salt Lake City	30	1.7	0.54	1.1	Aug 63
Vt:	Barre	29	2.0	0.19	1.0	Sep 63
Va:	Richmond	26	0.96	<0.10	0.56	Sep 63
Wash:	Seattle	24	1.6	0.16	0.62	Jul 63
W. Va:	Charleston	22	1.1	0.24	0.67	Dec 63
Wisc:	Madison	29	1.1	0.18	0.77	Sep 63
Wyo:	Cheyenne	24	2.3	0.59	1.0	Aug 63
Network summary		1,719	4.4	<0.10	0.85	

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10% of the average, a less-than sign is placed in front of the average.

TABLE 2. GROSS BETA ACTIVITY IN PRECIPITATION, DECEMBER 1963

Station location		Average concentration [a] (pc/liter)	Total deposition [a] (nc/m²)
Alaska:			
	Anchorage	290	3.2
	Fairbanks	640	3.9
	Juneau	330	47
Ark:	Little Rock	240	13
Calif:	Berkeley	500	7.5
	Los Angeles	[b]	[b]
Colo:	Denver	[b]	[b]
Conn:	Hartford	320	21
D.C:	Washington	500	14
Fla:	Jacksonville	310	14
	Miami	250	26
Ga:	Atlanta	510	2.3
Hawaii:	Honolulu	200	2.0
Idaho:	Boise	[b]	[b]
Ill:	Springfield	[b]	[b]
Ind:	Indianapolis	320	6.0
Iowa:	Iowa City	570	10
Kans:	Topeka	470	13
Ky:	Frankfort	440	6.1
La:	New Orleans	250	32
Maine:	Augusta	380	19
	Presque Isle	[b]	[b]
Md:	Baltimore	490	4.9
Mass:	Lawrence	460	26
	Winchester	470	37
Mich:	Lansing	1,580	28
Minn:	Minneapolis	240	4.0
Miss:	Jackson	270	23
Mo:	Jefferson City	480	5.8
Mont:	Helena	630	18
Nebr:	Lincoln	[b]	[b]
Nev:	Las Vegas	[b]	[b]
N.J:	Trenton	260	3.9
N. Mex:	Santa Fe	890	2.6
N.Y:	Albany	270	12
N.C:	Gastonia	230	16
N. Dak:	Bismarck	610	12
Ohio:			
	Columbus	530	11
	Painesville	620	24
Okla:	Oklahoma City	[b]	[b]
	Ponca City	640	3.6
Ore:	Portland	290	20
Pa:	Harrisburg	390	4.4
P.R:	San Juan	260	4.8
R.I:	Providence	400	27
S.C:	Columbia	230	26
S. Dak:	Pierre	200	4.2
Tenn:	Nashville	510	19
Tex:	Austin	[b]	[b]
	El Paso	[b]	[b]
Utah:	Salt Lake City	560	8.3
Vt:	Barre	560	36
Va:	Richmond	240	16
Wash:	Seattle	360	26
W. Va:	Charleston	400	15
Wisc:	Madison	740	10
Wyo:	Cheyenne	1,300	10

[a] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by $D = <0.2\ P$ in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] No evaporated sample received.

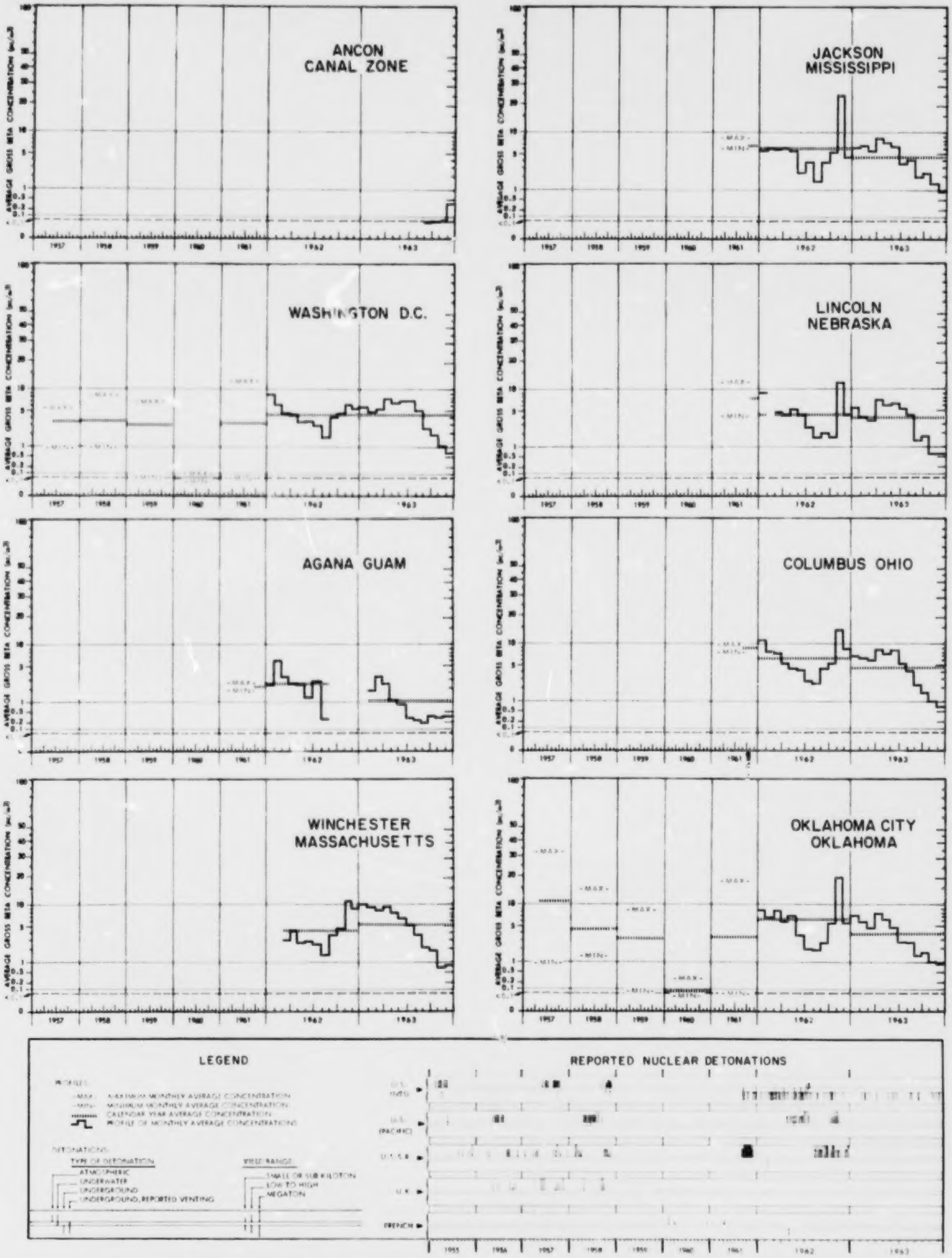

FIGURE 2.—MONTHLY AND YEARLY PROFILES OF BETA ACTIVITY IN AIR, RADIATION SURVEILLANCE NETWORK, 1957—DECEMBER 1963

2. National Air Sampling Network, Fourth Quarter and Annual Summary, 1963

Division of Air Pollution,
Public Health Service

The need for basic data on the nature and extent of air pollution throughout the United States led to the organization of the National Air Sampling Network (NASN) in 1953. The NASN analyzes air samples for the total quantity of suspended particulate matter, benzene-soluble organic matter, and gross beta radioactivity. Selected samples are also analyzed for nitrates, sulfates, and a number of metals. These analyses aid in the detection of trends in levels of pollution with respect to time, location, population density, climate, and other factors associated with air quality.

Gross Beta Activity in Air

NASN stations (see figure 3) are manned by cooperating Federal, State, and local agencies. The current basic network consists of 110 sampling stations which operate every year in 73 large cities and 37 nonurban areas. In addition, there are stations in 130 cities which operate every other year. Thus, there are 240 sampling stations in all in the NASN network, of which 175 are active in any given year.

Continuous 24-hour samples of suspended particulate matter are taken at each station. The samples, representing approximately 2,000 cubic meters of air, are collected on glass fiber filters on a biweekly random sampling schedule. They are then sent for analysis to the Network laboratory in Cincinnati, Ohio. Fourth quarter and annual summary 1963 data appear in tables 3 and 4.

Gross Beta Activity in Precipitation

The present reporting of gross beta activity in precipitation originated in 1959 when a precipitation collection and analysis program was established by the Weather Bureau Research Station in Cincinnati, Ohio, and the National Air Sampling Network. Precipitation is collected at 29 stations located at airports and Weather Bureau offices, and monthly composite

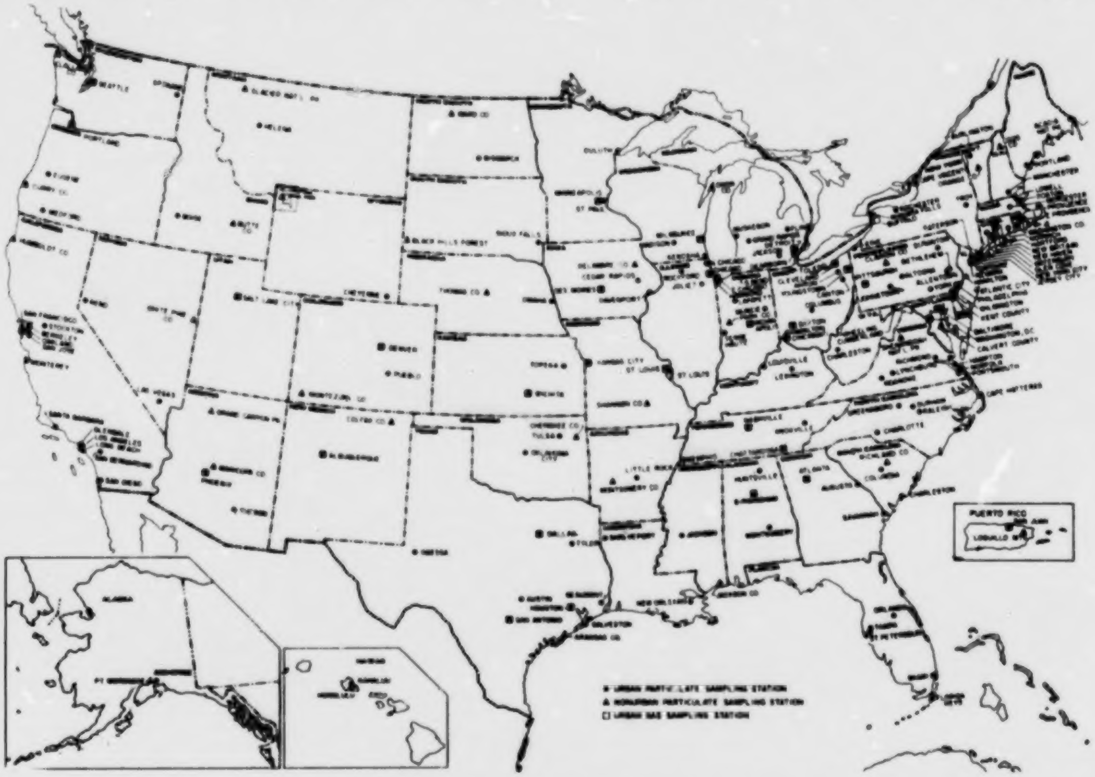
PUERTO RICO
● URBAN PARTICULATE SAMPLING STATION
▲ NONURBAN PARTICULATE SAMPLING STATION
□ URBAN GAS SAMPLING STATION

FIGURE 3.—NATIONAL AIR SAMPLING NETWORK SAMPLING STATIONS, 1963

TABLE 3.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, FOURTH QUARTER, 1963

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	6	3.5	0.7	2.2
	Huntsville	6	2.5	0.4	1.6
	Montgomery	6	3.8	1.2	2.4
Alaska:	Anchorage	6	2.4	<0.1	1.0
	Pt. Woronzof*	4	2.6	0.4	1.2
Ariz:	Grand Canyon Pk.*	6	2.9	1.4	2.3
	Maricopa County*	6	2.8	0.9	2.3
	Phoenix	6	2.4	0.6	1.5
	Tucson	6	2.6	1.9	2.2
Ark:	Little Rock	5	3.0	0.8	1.8
	Montgomery Co.*	6	2.7	1.4	2.0
Calif:	Berkeley	6	1.7	0.5	1.2
	Glendale	6	2.6	1.1	1.8
	Humboldt County*	5	2.4	0.5	1.6
	Long Beach	7	4.5	1.0	2.1
	Los Angeles	6	2.2	1.0	1.7
	Monterey	5	3.1	0.8	1.9
	Oakland	6	2.8	0.8	1.7
	San Bernardino	5	2.8	1.0	2.2
	San Diego	6	2.3	1.1	1.8
	San Francisco	6	2.1	0.6	1.4
	San Jose	6	3.3	0.9	1.7
	Santa Barbara	6	2.1	0.9	1.6
	Stockton	6	4.2	0.4	2.0
Colo:	Denver	6	3.1	1.2	1.9
	Montezuma County*	5	2.8	1.1	1.7
	Pueblo	6	2.9	1.1	1.7
Conn:	Hartford	6	3.1	0.2	1.9
	New Britain	6	4.0	0.2	2.0
	New Haven	5	3.7	0.2	2.0
	Norwich	6	3.3	0.2	1.7
	Waterbury	6	3.2	0.2	1.4
Del:	Kent County*	5	2.6	1.0	2.1
	Wilmington	7	2.6	0.2	1.8
D.C:	Washington	6	2.2	0.2	1.5
Fla:	Florida Keys*	6	3.7	1.4	2.1
	Miami	7	3.3	1.6	2.3
	Orlando	5	2.7	1.3	1.8
	St. Petersburg	7	4.7	0.2	2.2
	Tampa	6	3.5	1.3	2.3
Ga:	Atlanta	7	3.3	0.5	1.9
	Augusta	6	3.2	0.6	2.0
	Savannah	6	2.1	1.1	1.6
Hawaii:	Honolulu	6	1.8	0.5	0.9
	Kahaluu*	6	2.2	0.5	1.1
Idaho:	Boise	6	4.4	0.7	2.0
	Butte County*	6	4.1	0.9	2.1
Ill:	Chicago	7	4.7	0.6	1.7
	East St. Louis	5	4.6	0.7	1.8
	Joliet	6	3.7	0.2	1.2
	North Chicago	5	3.8	0.6	1.4
	Rockford	6	3.8	0.7	1.5
Ind:	East Chicago	5	5.8	0.6	2.4
	Hammond	6	3.7	0.7	1.4
	Indianapolis	6	8.4	0.8	3.1
	Parke County*	5	3.7	0.4	1.6
	Muncie	6	3.7	0.5	1.8
	South Bend	6	3.6	0.5	1.3
	Terre Haute	6	3.1	0.8	1.5
Iowa:	Cedar Rapids	6	4.6	0.7	1.6
	Davenport	6	1.5	0.5	0.9
	Delaware County*	6	3.7	0.4	1.4
	Des Moines	6	4.2	0.4	1.5
Kans:	Topeka	6	3.8	0.9	1.7
	Wichita	6	4.4	1.2	2.1
Ky:	Lexington	6	3.2	0.5	1.8
	Louisville	4	3.3	0.3	1.6
La:	New Orleans	6	4.1	1.7	2.3
	Shreveport	6	3.3	1.7	2.3
Maine:	Acadia Nat'l. Park*	6	2.3	0.9	1.7
	Portland	6	2.7	0.5	1.6
Md:	Baltimore	6	2.5	0.2	1.3
	Calvert County*	6	2.7	0.3	1.7
	Cumberland	6	2.6	0.2	1.4
Mass:	Boston	6	3.0	0.4	1.6
	Lowell	6	3.9	0.3	2.2
	Worcester	6	2.8	0.2	1.5
Mich:	Dearborn	7	3.5	0.7	1.7
	Detroit	6	3.0	0.5	1.5
	Flint	6	3.9	0.6	1.5
	Grand Rapids	7	4.2	0.4	1.5
	Jackson	6	3.8	0.6	1.6
	Muskegon	6	3.6	0.4	1.3
Minn:	Duluth	6	4.2	0.3	1.7
	Minneapolis	6	3.4	0.4	1.2
	St. Paul	6	3.9	0.4	1.4
Miss:	Jackson	7	3.4	1.3	2.4
	Jackson County*	4	3.3	1.8	2.5
Mo:	Kansas City	6	4.1	0.9	1.8
	Shannon County*	6	4.3	1.4	2.4
	St. Louis	6	2.9	0.5	1.1
Mont:	Glacier Nat'l. Park*	5	2.3	0.5	1.4
	Helena	6	4.0	0.6	1.8
Nebr:	Omaha	6	4.7	0.6	1.8
	Thomas County*	6	5.3	0.8	2.4
Nev:	Las Vegas	5	2.9	1.3	2.1
	Reno	7	6.9	0.4	3.0
	White Pine Co.*	7	4.9	1.1	2.3
N.H:	Coos County*	6	2.0	0.2	1.2
N.J:	Atlantic City	6	4.0	0.2	2.0
	Bayonne	6	3.5	1.2	1.8
	Hamilton	6	3.4	0.2	1.8
	Jersey City	6	3.9	0.2	1.7
	Newark	6	3.6	0.8	1.9
	Paterson	7	2.5	0.2	1.6
N.M:	Albuquerque	6	3.0	1.0	1.9
N.Y:	Cape Vincent*	6	2.8	0.2	1.4
	Massena	6	2.8	0.4	1.7
	New York	5	4.3	0.2	2.1
	Niagara Falls	6	2.9	0.1	1.2
	Rochester	5	2.9	0.3	1.7
	Troy	6	2.9	0.2	1.7
N.C:	Cape Hatteras*	7	3.3	0.5	2.0
	Charlotte	6	2.4	0.6	1.6
	Durham	7	1.9	0.2	0.9
	Greensboro	6	2.4	0.3	1.5
	Raleigh	5	2.8	1.7	2.2
N. Dak:	Bismarck	6	3.4	0.8	1.4
	Ward County*	5	2.4	0.7	1.3
Ohio:	Akron	5	3.0	0.3	1.5
	Canton	6	3.5	0.2	1.8
	Cincinnati	6	2.2	0.8	1.6
	Cleveland	6	3.7	0.4	2.1
	Columbus	6	3.0	0.6	1.5
	Dayton	6	3.2	0.7	1.7
	Hamilton	6	2.6	0.7	1.6
	Toledo	6	4.0	0.4	2.1
	Youngstown	6	3.9	0.3	1.8
Okla:	Cherokee County*	5	2.6	0.9	1.8
	Oklahoma City	3	3.3	2.1	2.7
	Tulsa	6	2.6	1.3	1.9
Ore:	Curry County*	3	0.8	0.2	0.5
	Eugene	5	1.7	0.3	1.1
	Medford	6	4.4	0.4	1.6
	Portland	7	2.8	0.7	1.4
Pa:	Allentown	7	2.1	0.1	1.2
	Altoona	6	2.4	0.3	1.5
	Bethlehem	6	2.9	0.9	2.1
	Clarion County*	5	2.5	0.6	1.3
	Erie	6	3.3	0.4	1.8
	Johnstown	6	2.2	0.9	1.7
	Philadelphia	7	2.9	0.2	1.6
	Pittsburgh	6	2.6	0.3	1.5
	Scranton	6	2.4	0.2	1.5
	York	6	2.9	1.4	2.2
R. I:	East Providence	6	3.2	0.8	1.6
	Providence	5	3.3	1.0	2.1
	Washington Co.*	6	3.3	0.3	1.8
S. C:	Charleston	6	3.2	0.6	1.9
	Columbia	5	1.9	0.5	1.5
	Richland County*	6	3.1	1.4	2.0
S. Dak:	Black Hills*	7	3.4	0.9	1.8
	Sioux Falls	5	4.4	0.2	1.3
Tenn:	Chattanooga	4	3.6	1.2	2.4
	Knoxville	6	3.1	0.3	1.6
	Memphis	4	3.3	1.4	2.4
	Nashville	6	2.8	0.5	1.7
Tex:	Aransas County*	6	3.3	0.8	2.0
	Austin	6	2.6	0.7	1.8
	Beaumont	4	3.4	1.5	2.3
	Dallas	6	2.7	1.2	1.7
	Galveston	5	4.7	2.0	2.9
	Houston	5	3.7	1.3	2.0
	Odessa	7	3.6	0.5	2.0
	San Antonio	6	2.5	0.5	1.8
	Tyler	6	5.3	1.4	2.6
Utah:	Salt Lake City	6	4.2	1.3	2.2
Vt:	Burlington	6	2.5	0.3	1.3
	Orange County*	6	2.3	0.2	1.3
Va:	Hampton	6	2.9	0.7	1.8
	Lynchburg	3	1.8	0.3	1.0
	Norfolk	6	3.5	0.5	1.8
	Portsmouth	6	2.0	0.3	1.3
	Richmond	6	2.8	0.6	1.7
	Roanoke	6	3.8	0.3	1.7
	Shenandoah Park*	6	3.1	0.2	1.7
Wash:	Clallam County*	4	2.6	0.9	1.6
	Seattle	6	2.8	0.5	1.4
	Spokane	5	1.4	0.6	1.1
W. Va:	Charleston	6	3.0	0.4	1.7
	Wheeling	3	2.6	1.3	1.8
Wis:	Door County*	6	2.0	1.0	1.5
	Kenosha	5	3.7	0.7	1.4
	Madison	6	4.6	0.5	1.5
	Milwaukee	6	2.5	0.5	1.2
Wyo:	Cheyenne	6	3.1	0.7	1.8
	Yellowstone Park*	5	4.9	0.7	2.0
Network summary		1079	8.4	<0.1	1.7

* Nonurban station.

TABLE 4.—FISSION PRODUCT GROSS BETA ACTIVITY IN SURFACE AIR, ANNUAL SUMMARY, 1963

[Concentrations in pc/m³]

Stations		Number of samples	Maximum	Minimum	Average
Ala:	Birmingham	26	15.8	0.2	7.2
	Huntsville	25	19.8	0.4	7.9
	Montgomery	26	16.3	1.2	7.2
Alaska:	Anchorage	26	17.6	<0.1	4.5
	Pt. Woronzof*	24	19.5	0.3	5.4
Ariz:	Grand Canyon Pk.*	26	47.2	1.1	11.3
	Maricopa County*	26	29.7	0.9	10.8
	Phoenix	25	26.7	0.6	9.3
	Tucson	25	30.4	0.7	9.5
Ark:	Little Rock	18	14.3	0.8	6.4
	Montgomery County*	24	19.2	1.4	6.4
Calif:	Berkeley	20	24.4	0.5	4.2
	Glendale	26	32.2	1.1	8.9
	Humboldt County*	22	24.6	0.3	3.9
	Long Beach	25	24.6	1.0	7.8
	Los Angeles	26	30.0	1.0	7.2
	Monterey	20	10.1	0.8	4.3
	Oakland	25	27.5	0.8	6.1
	San Bernardino	23	25.2	1.0	11.2
	San Diego	25	29.7	1.1	7.1
	San Francisco	26	25.6	0.6	5.3
	San Jose	26	29.6	0.9	5.8
	Santa Barbara	25	31.4	0.9	6.7
	Stockton	26	12.4	0.4	5.7
Colo:	Denver	25	34.6	1.2	9.0
	Montezuma County*	25	27.6	1.1	9.2
	Pueblo	25	29.6	1.1	8.7
Conn:	Hartford	26	23.2	0.2	6.3
	New Britain	22	15.4	0.2	5.3
	New Haven	25	21.6	0.2	6.6
	Norwich	26	30.0	0.2	7.3
	Waterbury	25	14.9	0.2	4.8
Del:	Kent County*	19	12.0	1.0	5.3
	Wilmington	25	16.5	0.2	6.3
D.C:	Washington	25	28.5	0.2	7.4
Fla:	Florida Keys*	25	18.6	0.4	7.1
	Miami	25	23.4	1.2	8.0
	Orlando	22	18.7	0.4	6.3
	St. Petersburg	26	21.6	0.2	6.4
	Tampa	23	18.5	0.7	6.1
Ga:	Atlanta	26	16.0	0.1	6.6
	Augusta	25	17.9	0.6	6.6
	Savannah	26	19.2	0.7	6.2
Hawaii:	Honolulu	26	12.4	0.5	3.6
	Kahaluu*	26	12.8	0.5	4.2
Idaho:	Boise	23	26.5	0.7	8.7
	Butte County*	25	30.0	0.9	10.8
Ill:	Chicago	24	16.4	0.6	6.1
	East St. Louis	23	28.5	0.7	7.6
	Joliet	26	19.1	0.2	6.7
	North Chicago	23	27.3	0.6	7.9
	Rockford	23	18.2	0.7	6.7
Ind:	East Chicago	19	16.8	0.4	5.4
	Hammond	26	16.3	0.7	6.7
	Indianapolis	23	20.0	0.8	8.1
	Parke County*	25	17.3	0.4	8.0
	Muncie	25	20.7	0.5	7.4
	South Bend	26	19.4	0.5	7.2
	Terre Haute	24	22.6	0.8	8.0
Iowa:	Cedar Rapids	26	14.9	0.7	6.7
	Davenport	25	49.3	0.5	7.4
	Delaware County*	25	15.0	0.4	5.7
	Des Moines	26	22.6	0.4	6.0
Kans:	Topeka	26	14.0	0.9	5.7
	Wichita	26	19.0	1.2	7.1
Ky:	Lexington	24	16.5	0.5	7.1
	Louisville	19	19.1	0.3	7.7
La:	New Orleans	26	17.5	.4	6.7
	Shreveport	22	17.8	1.5	6.9
Maine:	Acadia Nat'l. Park*	22	12.0	0.9	4.1
	Portland	25	15.5	0.5	5.8
Md:	Baltimore	26	15.6	0.2	6.0
	Calvert County*	26	17.0	0.3	6.7
	Cumberland	26	19.6	0.2	6.6
Mass:	Boston	22	16.8	0.4	5.4
	Lowell	26	29.6	0.3	9.7
	Worcester	26	19.3	0.2	6.2
Mich:	Dearborn	26	21.3	0.7	7.0
	Detroit	26	17.2	0.5	6.0
	Flint	23	17.8	0.6	5.8
	Grand Rapids	24	17.4	0.4	6.2
	Jackson	26	20.4	0.6	7.7
	Muskegon	25	17.8	0.4	5.9
Minn:	Duluth	25	18.3	0.3	5.8
	Minneapolis	26	16.4	0.4	6.2
	St. Paul	26	20.9	0.4	7.1
Miss:	Jackson	23	18.4	1.3	7.6
	Jackson County*	19	18.0	1.0	6.4
Mo:	Kansas City	24	17.2	0.7	6.6
	Shannon County*	22	19.6	1.3	8.1
	St. Louis	25	17.8	0.5	7.0
Mont:	Glacier Nat'l. Park*	20	19.2	0.5	5.9
	Helena	26	22.6	0.6	7.8
Nebr:	Omaha	25	13.7	0.6	6.5
	Thomas County*	25	20.4	0.8	7.6
Nev:	Las Vegas	22	34.1	1.0	12.5
	Reno	24	18.6	0.4	9.0
	White Pine Co.*	25	36.5	1.1	10.3
N. H:	Coos County*	19	15.3	0.2	6.9
N. J:	Atlantic City	25	14.6	0.2	6.3
	Bayonne	24	19.8	1.2	5.6
	Hamilton	23	16.6	0.2	6.4
	Jersey City	23	32.8	0.2	6.0
	Newark	26	18.0	0.8	6.3
	Paterson	26	22.0	0.2	6.2
N. Mex:	Albuquerque	25	25.6	0.8	7.8
	Colfax County*	18	38.4	0.4	12.1
N. Y:	Cape Vincent*	25	20.3	0.2	6.4
	Massena	26	17.9	0.4	6.1
	New York	25	24.2	0.2	8.6
	Niagara Falls	26	17.8	0.1	6.8
	Rochester	25	16.0	0.3	6.1
	Troy	21	15.7	0.2	5.4
N. C:	Cape Hatteras*	24	16.7	0.5	6.6
	Charlotte	26	18.6	0.6	7.6
	Durham	26	19.7	0.2	6.8
	Greensboro	26	26.0	0.3	7.9
	Raleigh	24	18.5	1.5	6.1
N. Dak:	Bismarck	26	17.6	0.8	6.3
	Ward County*	24	16.0	0.7	6.5
Ohio:	Akron	25	16.9	0.3	6.9
	Canton	26	14.4	0.2	6.4
	Cincinnati	26	17.6	0.8	7.5
	Cleveland	24	18.8	0.4	7.2
	Columbus	26	16.4	0.6	7.0
	Dayton	26	18.4	0.7	7.5
	Hamilton	26	19.4	0.7	8.0
	Toledo	26	19.3	0.4	7.1
	Youngstown	26	15.5	0.3	6.7
Okla:	Cherokee County*	24	16.2	0.9	6.3
	Oklahoma City	19	22.5	1.9	6.9
	Tulsa	25	18.4	1.3	7.1
Ore:	Curry County*	20	10.8	0.2	3.7
	Eugene	21	24.1	0.3	4.3
	Medford	24	9.2	0.4	3.7
	Portland	23	22.0	0.7	4.4
Pa:	Allentown	26	14.2	0.1	4.9
	Altoona	22	14.4	0.3	6.8
	Bethlehem	26	15.7	0.9	7.4
	Clarion County*	21	15.4	0.6	5.7
	Erie	25	20.7	0.4	7.2
	Johnstown	23	13.0	0.9	6.9
	Philadelphia	25	15.6	0.2	6.8
	Pittsburgh	25	15.7	0.3	6.4
	Scranton	26	24.1	0.2	6.0
	York	26	22.0	1.4	7.8
R. I:	East Providence	25	16.8	0.3	6.5
	Providence	21	17.1	1.0	6.1
	Washington Co.*	26	24.6	0.3	7.0
S. C:	Charleston	25	23.8	0.6	7.6
	Columbia	23	13.2	0.5	5.7
	Richland County*	24	25.6	1.4	9.6
S. Dak:	Black Hills*	26	25.1	0.9	8.2
	Sioux Falls	23	13.5	0.2	6.2
Tenn:	Chattanooga	24	18.4	1.2	7.6
	Knoxville	25	14.5	0.3	6.6
	Memphis	23	17.5	1.4	8.5
	Nashville	26	21.0	0.5	7.6
Tex:	Aransas County*	24	17.5	0.8	6.1
	Austin	26	22.2	0.7	7.3
	Beaumont	16	21.5	1.1	5.9
	Dallas	23	16.6	1.1	5.6
	Galveston	23	15.0	1.2	6.2
	Houston	22	16.7	1.3	6.7
	Odessa	25	19.0	0.5	6.5
	San Antonio	24	21.1	0.5	6.6
	Tyler	26	22.8	1.4	7.4
Utah:	Salt Lake City	26	26.4	1.3	10.3
Vt:	Burlington	21	18.0	0.1	6.2
	Orange County*	26	17.6	0.2	6.3
Va:	Hampton	26	12.2	0.7	5.5
	Lynchburg	21	21.3	0.3	7.8
	Norfolk	25	15.3	0.5	6.8
	Portsmouth	25	13.1	0.3	5.9
	Richmond	25	13.6	0.6	6.3
	Roanoke	21	18.1	0.3	8.2
	Shenandoah Park*	26	20.3	0.2	7.2
Wash:	Clallam County*	19	10.0	0.9	4.0
	Seattle	26	23.0	0.5	4.1
	Spokane	24	19.6	0.6	6.9
W. Va:	Charleston	26	21.4	0.4	7.4
	Wheeling	20	21.3	1.3	9.0
Wis:	Door County	24	17.8	1.0	7.1
	Kenosha	25	17.6	0.7	6.9
	Madison	26	18.7	0.5	6.8
	Milwaukee	26	16.0	0.5	6.2
Wyo:	Cheyenne	24	41.6	0.7	10.3
	Yellowstone Park*	25	24.6	0.7	10.4
Network summary		4,562	49.3	<0.1	6.9

* Nonurban station.

TABLE 5.—FISSION PRODUCT BETA ACTIVITY IN PRECIPITATION—NASN, FOURTH QUARTER, 1963

Station		October		November		December	
		pc/liter	nc/m^2	pc/liter	nc/m^2	pc/liter	nc/m^2
Ala:	Montgomery	—	—	83	5	211	25
Fla:	Tampa	—	—	59	8	271	12
La:	Lake Charles	—	—	45	4	98	6
Maine:	Caribou	560	29	87	10	—	—
Mass:	Nantucket	220	17	88	6	196	17
Mich:	Sault Ste. Marie	—	—	250	17	413	21
N. Y.:	Albany	—	—	177	17	405	19
N. C.:	Hatteras	92	12	69	5	252	23
Pa:	Philadelphia	—	—	127	19	392	18
S. C.:	Charleston	290	13	78	10	100	8
	Greenville	—	—	104	11	204	20
Tenn:	Nashville	—	—	125	5	152	9
Texas:	Brownsville	—	—	—	—	369	19
	San Angelo	—	—	84	4	—	—
Va:	Sterling	—	—	62	10	224	17
Wash:	Tatoosh	210	54	105	24	232	51

samples are forwarded to the Cincinnati laboratory for analysis.

The laboratory analyzes these samples for total solids and for a large number of metals and nonmetals. In addition, each sample is analyzed for fission product gross beta radioactivity if a sufficient volume of precipitation remains after chemical analyses have been made. Precipitation data for the fourth quarter 1963 are presented in table 5.

3. Canadian Air Monitoring Program,[3] December 1963

Department of National Health and Welfare, Ottawa, Canada

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 4), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3-7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}-Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for December 1963 are given in table 6 and presented in conjunction with

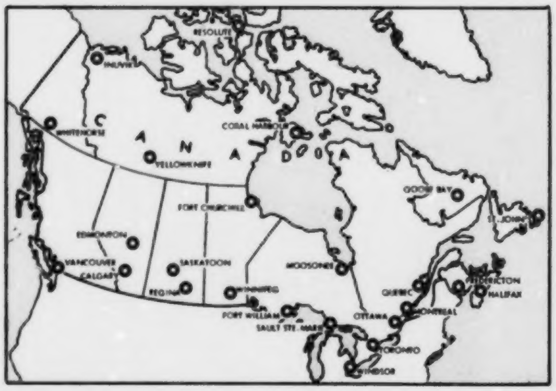

FIGURE 4.—CANADIAN AIR AND PRECIPITATION SAMPLING STATIONS, DECEMBER 1963

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[3] Data from *Radiation Protection Programs*, 2:11-24, Radiation Protection Division, Canadian Department of National Health and Welfare (January 1964).

TABLE 6.—FISSION PRODUCT GROSS BETA ACTIVITY IN AIR, CANADA, DECEMBER 1963

[Average concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Calgary	29	2.6	0.0	1.1
Coral Harbour	31	1.4	0.2	0.8
Edmonton	30	1.4	0.4	0.9
Ft. Churchill	31	1.7	0.1	0.8
Ft. William	30	1.7	0.4	1.1
Fredericton	31	1.4	0.3	0.8
Goose Bay	30	1.2	0.1	0.7
Halifax	28	2.1	0.4	1.0
Inuvik	31	2.4	0.5	1.0
Montreal	29	2.3	0.3	0.9
Moosonee	30	1.4	0.1	0.9
Ottawa	30	1.3	0.4	0.8
Quebec	29	1.7	0.1	0.9
Regina	31	2.3	0.3	0.9
Resolute	31	1.9	0.1	0.8
St. John's, Nfld.	31	2.1	0.1	0.7
Saskatoon	30	2.1	0.4	0.9
Sault Ste. Marie	31	1.4	0.3	0.9
Toronto	31	0.5	0.1	0.3
Vancouver	31	1.9	0.2	0.7
Whitehorse	31	1.5	9.2	0.6
Windsor	30	1.8	0.4	0.9
Winnipeg	31	1.8	0.5	0.9
Yellowknife	30	1.3	0.3	0.8
Network summary	727	2.6	0.0	0.8

TABLE 7.—FISSION PRODUCT GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, DECEMBER 1963

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	588	12.4
Coral Harbour	1487	12.1
Edmonton	739	7.5
Ft. Churchill	427	7.5
Ft. William	301	8.0
Fredericton	146	9.8
Goose Bay	102	10.2
Halifax	250	43.7
Inuvik	511	6.1
Montreal	353	10.3
Moosonee	2894	49.9
Ottawa	195	5.8
Quebec	1111	46.8
Regina	501	5.3
Resolute	398	17.2
St. John's, Nfld.	518	40.9
Saskatoon	415	4.1
Sault Ste. Marie	364	33.0
Toronto	537	14.7
Vancouver	381	91.8
Whitehorse	468	7.3
Windsor	364	13.9
Winnipeg	506	13.6
Yellowknife	353	2.9
Average	580	19.8

U. S. and Mexican data by an isogram map (figure 6).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450°C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}-Y^{90} source. Gross beta activities for December samples are given in table 7. Radionuclide analyses appear quarterly.

4. Mexican Air Monitoring Program, December 1963

National Commission of Nuclear Energy, Mexico

The Radiation Surveillance Network of Mexico was established by the Comision Nacional de Energia Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network consists of 17 stations (see figure 5), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Instituto de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

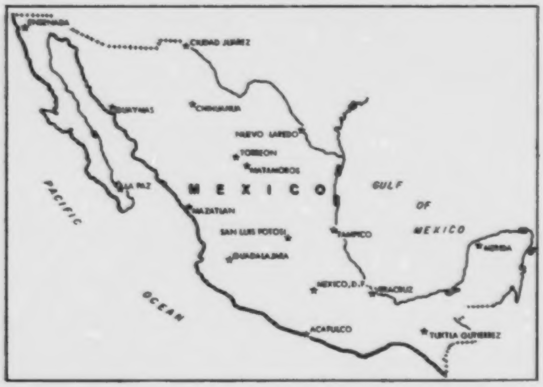

FIGURE 5.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

TABLE 8.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, DECEMBER 1963

[Concentrations in pc/m³]

Station	Number of Samples	Maximum	Minimum	Average
Acapulco	10	0.7	0.1	0.2
Ciudad Juárez	18	2.8	0.1	1.0
Chihuahua	18	2.2	0.4	1.2
Ensenada	9	2.9	0.6	1.4
Guadalahara	5	2.1	0.2	0.9
Guaymas [a]				
La Paz	11	2.4	0.6	1.4
Matamoros	2	2.2	0.8	
Mazatlán [a]				
Mérida	7	2.3	0.2	1.0
Mexico City	20	0.9	0.1	0.2
Nuevo Laredo [a]				
San Luis Potosí	18	1.4	<0.1	0.3
Tampico	8	1.2	0.1	0.6
Torreón	8	1.9	0.2	1.1
Tuxtla Gutiérrez [a]				
Veracruz	6	0.9	<0.1	0.1

[a] Equipment out of order.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency glass fiber filter, 6 x 8 inch, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during December 1963 are presented in table 8. The data are also represented in the beta activity isogram map of North America, figure 6.

5. Pan American Air Sampling Program, December 1963

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas to develop their own radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile, is operated by the Occupational Health Service; in Lima, Peru, by the Institute of Occupational Health; and in Caracas, Venezuela, by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The December 1963 air monitoring results from the three participating countries are given in table 9. The Caracas station is shown on the gross beta concentration isogram map (figure 6). The December average at this station, adjusted by the RSN intercalibration factor,[4] is less than 0.28 pc/m^3, which is considerably below the lowest isogram used on the map (1 pc/m^3).

TABLE 9.—GROSS BETA ACTIVITY IN AIR, DECEMBER 1963

[Concentrations in pc/m^3]

Sampling stations	Number of Samples	Maximum	Minimum	Average [a]
Caracas, Venezuela	23	0.49	<0.10	0.22
Lima, Peru	14	0.18	<0.10	<0.13
Santiago, Chile	13	0.24	<0.10	<0.13

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

6. Gross Beta Activity in Air, North America, December 1963

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[5] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the new 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are, therefore, not the same as were previously used.

Figure 6 shows the December 1963 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

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[4] The RSN factor is 1.28 (see below).

[5] The January through October 1963 Isogram Maps were published in the May 1963 through February 1964 issues of *Radiological Health Data*.

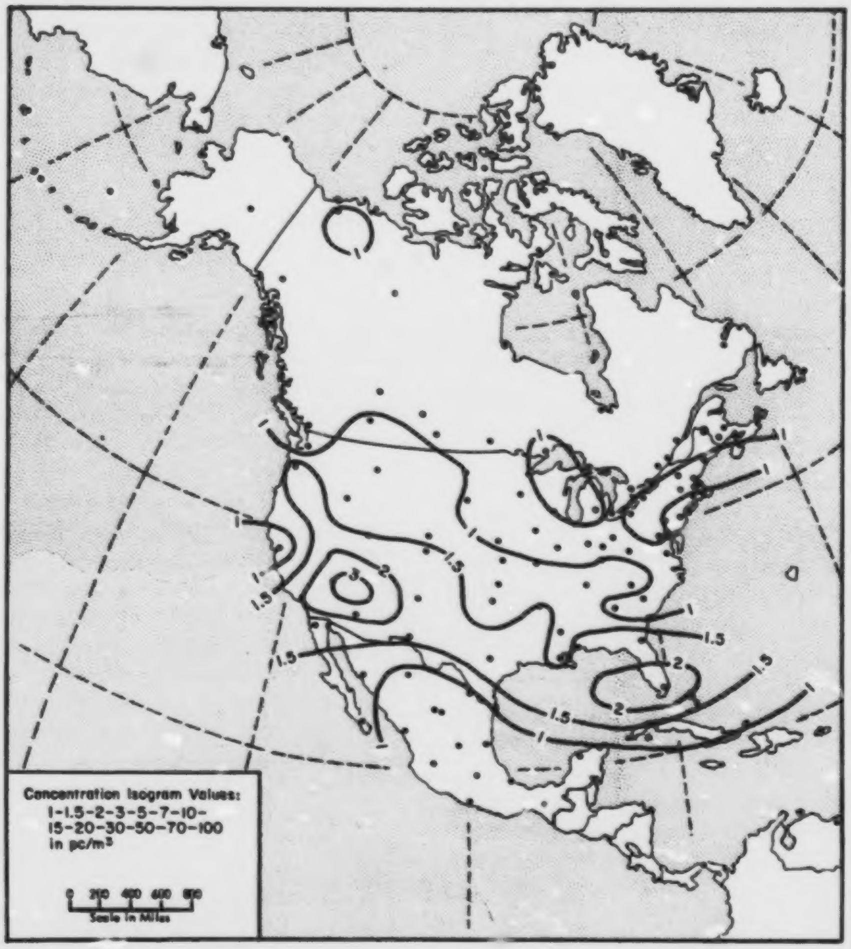

FIGURE 6.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, DECEMBER 1963

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STRONTIUM-90 DEPOSITION ON THE EARTH'S SURFACE—1962[1]

William R. Collins Jr.[2]

Quarterly strontium-90 deposition figures by latitude bands, based on the world-wide pot and resin column collections made by the Health and Safety Laboratory (HASL) during 1958 through 1961, have been reported previously (*1, 2*). Similar data for 1962 are given below with a review of the previous data for comparison. The locations of the sampling sites are shown in figure 1.

In previous years strontium-89 and tungsten-185 measurements have been used to estimate relative contributions of different sources to total fallout radioactivity. During 1962, strontium-89 measurements were used as a means of distinguishing between old debris and that from nuclear test series conducted during 1961 and 1962.

Average monthly strontium-90 deposition figures for 1962 for each ten degrees of latitude from 80° north to 50° south are presented in table 1. Yearly sums of these values for each of the latitude bands are listed under the monthly values in table 1 and are plotted in figure 2. In this calculation, as discussed previously (*2*), it is assumed that the mean value for the selected sites is representative of the entire latitude band; the effects of rainfall differences are not considered. Estimates of total quarterly hemispheric depositions of strontium-90 for 1958-1962 are listed in table 2 and are plotted in figure 3.

From the data it was estimated that 1.49 megacuries of strontium-90 were deposited on the earth's surface during 1962. If it is assumed that the fallout patterns illustrated in figure 3 for 1960 and the first 3 quarters of 1961 represent a trend toward stabilization of deposition rates from premoratorium test series, it is unlikely that the 1962 depositions of strontium-90 in the Northern and Southern Hemispheres would have exceeded 0.22 and 0.12 megacuries, respectively. The actual values are 1.26 and 0.23 megacuries. Thus, at

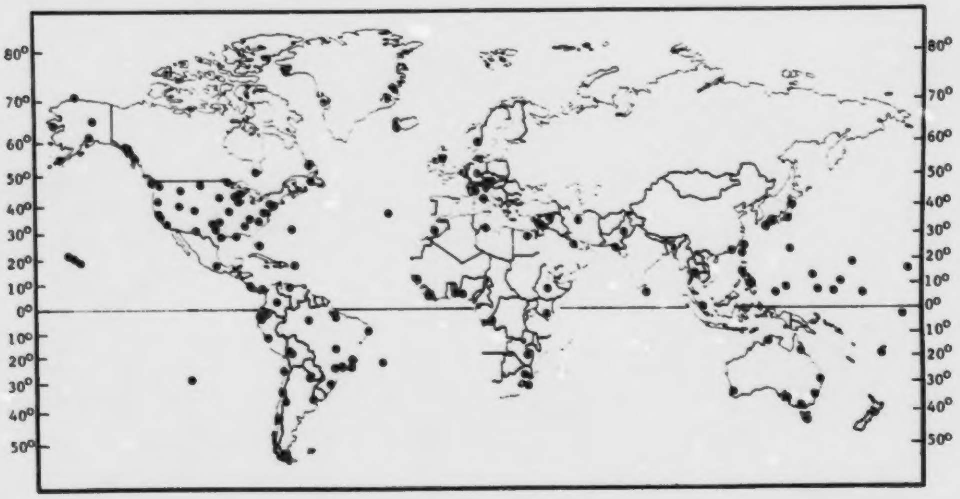

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

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[1] Summarized from Atomic Energy Commission: *Fallout Program Quarterly Summary Report, HASL-140*: 240-247, Washington, D. C. 20430 (October 1, 1963).

[2] Mr. Collins is a staff member of the Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York 14, N. Y.

TABLE 1.—1962 AVERAGE STRONTIUM-90 FALLOUT RATE BY 10° BANDS OF LATITUDE

Latitude bands	80–70°N	70–60°N	60–50°N	50–40°N	40–30°N	30–20°N	20–10°N	10–0°N	0–10°S	10–20°S	20–30°S	30–40°S	40–50°S
No. of sites	2	4	6	20	26	12	12	12	10	7	10	8	2
1962 Monthly deposition (mc/mi²)													
January	0.01	0.78	0.89	0.86	1.66	1.68	0.42	0.38	0.57	0.23	0.29	0.26	0.90
February	0.01	0.88	0.75	1.52	2.29	1.61	0.51	1.05	0.28	0.16	0.22	0.23	0.10
March	0.01	0.74	1.06	1.74	2.38	2.63	0.56	1.12	0.22	0.09	0.18	0.21	0.20
April	0.16	1.17	0.80	2.65	2.20	1.75	1.00	0.59	1.16	0.04	0.09	0.07	0.11
May	1.06	0.80	2.68	4.48	1.89	2.40	0.78	0.73	0.52	0.07	0.16	0.11	0.14
June	0.60	1.78	2.55	2.80	1.62	1.13	0.78	0.70	0.78	0.18	0.09	0.18	0.21
July	0.31	1.21	1.65	1.95	0.91	0.79	0.72	0.74	0.14	0.13	0.25	0.17	0.18
August	0.64	1.34	1.67	1.98	0.45	0.58	0.46	0.67	0.25	0.09	0.18	0.22	0.16
September	0.80	1.38	1.96	1.06	0.53	0.98	0.27	0.23	0.13	0.22	0.27	0.20	0.16
October	0.12	0.74	1.04	1.10	0.81	0.77	0.20	0.21	0.15	0.13	0.43	0.20	0.66
November	0.09	0.79	1.01	1.35	1.33	0.61	0.20	0.34	0.12	0.28	0.48	0.26	0.22
December	0.04	0.84	0.97	0.84	1.23	0.83	0.24	0.27	0.26	0.31	0.55	0.26	0.21
1962 Total deposition (mc/mi²)	3.85	12.45	17.03	22.23	17.30	15.76	6.14	7.03	4.58	1.93	3.19	2.37	3.25
(nc/m²)	1.49	4.81	6.57	8.62	6.68	6.08	2.37	2.71	1.77	0.74	1.23	0.91	1.25
Total Sr^{90} deposition during 1962 (Megacuries)	0.017	0.090	0.168	0.271	0.244	0.246	0.102	0.120	0.078	0.032	0.050	0.033	0.040

least 83 percent of the northern hemispheric deposition, 48 percent of the southern hemispheric deposition and 77 percent of the total global deposition during 1962 originated from the 1961 and 1962 tests.

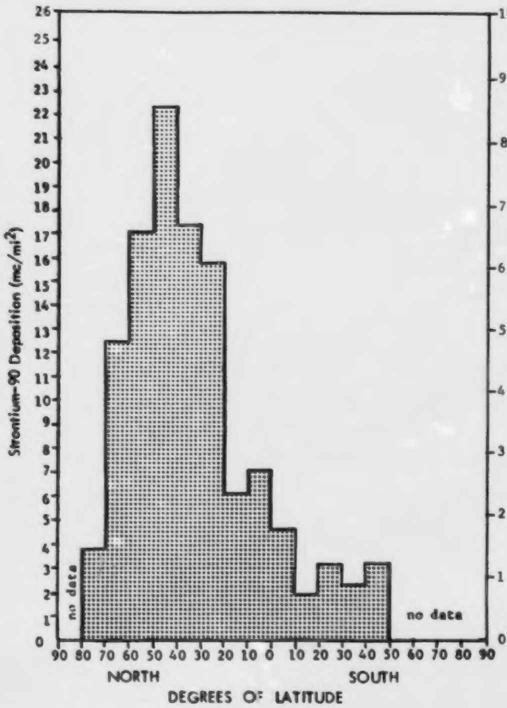

FIGURE 2.—TOTAL STRONTIUM-90 DEPOSITION DURING 1962 *VS* LATITUDE BAND

Average Sr^{89}/Sr^{90} ratios obtained for each ten degrees of latitude covered by the sampling program are listed in table 3, and average ratios for the Northern Hemisphere (10°-80°N), the equatorial region (10°N-10°S), and the Southern Hemisphere (10°-50°S) are plotted by sampling month in figure 4. The lengths of the post-moratorium test series relative to the 30 day sampling period and the 50.5-day half-life of strontium-89 limit the usefulness of these measurements in distinguishing between sources of debris. However, the isotope ratios do indicate that debris from the 1961 Soviet tests continued to arrive in the Northern Hemisphere during 1962 with no significant penetrations to latitudes below 10°S. Debris from U. S. equatorial tests conducted during the late spring and early summer of 1962 pre-

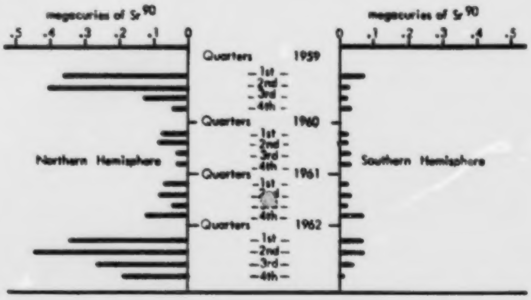

FIGURE 3.—QUARTERLY DEPOSITION OF STRONTIUM-90, 1959-1962

TABLE 2.—ESTIMATES OF TOTAL STRONTIUM-90 DEPOSITION BY HEMISPHERE AND QUARTER

[Megacuries]

Period	Northern Hemisphere	Southern Hemisphere	Northern and Southern Hemispheres
1958			
First quarter			0.14
Second quarter			0.24
Third quarter			0.18
Fourth quarter			0.21
Total			0.77
1959			
First quarter	0.36	0.066	0.43
Second quarter	0.41	0.025	0.43
Third quarter	0.12	0.025	0.14
Fourth quarter	0.04	0.033	0.08
Total	0.93	0.149	1.08
1960			
First quarter	0.079	0.027	0.106
Second quarter	0.086	0.022	0.108
Third quarter	0.036	0.022	0.058
Fourth quarter	0.029	0.035	0.064
Total	0.230	0.106	0.336
1961			
First quarter	0.064	0.028	0.092
Second quarter	0.082	0.030	0.112
Third quarter	0.045	0.027	0.072
Fourth quarter	0.124	0.062	0.186
Total	0.315	0.147	0.462
1962			
First quarter	0.344	0.062	0.406
Second quarter	0.455	0.063	0.518
Third quarter	0.265	0.041	0.306
Fourth quarter	0.195	0.067	0.262
Total	1.259	0.233	1.492

dominated in fallout below 10°N latitude from April through August of 1963 and in fallout below 10°S latitude through the end of the year. Debris from the fall 1962 U.S.S.R. and U. S. tests appeared in mixed fallout from August through the end of the year, primarily at latitudes north of 10°S.

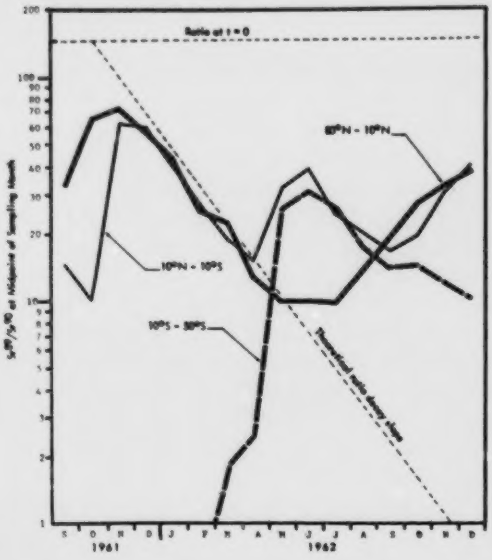

FIGURE 4.—RATIO OF STRONTIUM-89 TO STRONTIUM-90, BY SAMPLING MONTH FOR DIFFERENT GLOBAL REGIONS

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TABLE 3.—RATIOS OF STRONTIUM-89 TO STRONTIUM-90 AT MIDPOINT OF COLLECTION PERIOD BY 10° LATITUDE BANDS—1962

Period	80-70°N	70-60°N	60-50°N	50-40°N	40-30°N	30-20°N	20-10°N	10-0°N	0-10°S	10-20°S	20-30°S	30-40°S	40-50°S
January	34	49	45	43	42	44	44	48	36	1	<1	<1	<1
February	<1	30	26	33	28	29	29	25	26	2	1	<1	<1
March	20	43	23	18	20	18	28	18	19	3	3	1	<1
April	8	15	13	12	13	13	14	14	16	2	5	3	<1
May	8	10	8	9	11	10	14	18	46	20	39	36	10
June	2	8	10	8	10	13	19	37	41	35	55	22	11
July	[a]—	10	8	10	18	15	12	25	24	18	28	32	19
August	—	25	10	12	13	15	17	18	22	13	21	18	16
September	20	24	21	19	16	19	15	17	16	12	17	12	15
October	17	28	32	29	28	28	29	24	15	9	14	11	24
November	—	42	36	40	42	32	40	42	24	15	11	7	15
December	25	47	41	37	43	38	32	38	42	12	8	13	7

[a] No data received.

FISSION PRODUCT GAMMA ACTIVITY IN AIR— 80TH MERIDIAN NETWORK, NOVEMBER 1963

Health and Safety Laboratory, Atomic Energy Commission

Total gamma activity measurements for weekly ground-level air filter samples taken at 80th Meridian stations (see figure 1) during November 1963 are listed in table 1, together with monthly average concentrations and the ratios of the gamma photons in excess of 1 Mev to the total gamma activity. The November average total gamma concentrations are plotted in figure 2, as an activity-latitude profile and compared with the third quarter average profile. Details of sampling procedures and analytical methodology have previously been described (*1, 2*).

The November results in general show slight decreases in ground level air activity concentrations in both the Northern and the Southern Hemisphere with respect to results obtained for October 1963. Levels in the Northern Hemisphere remained about ten times higher than

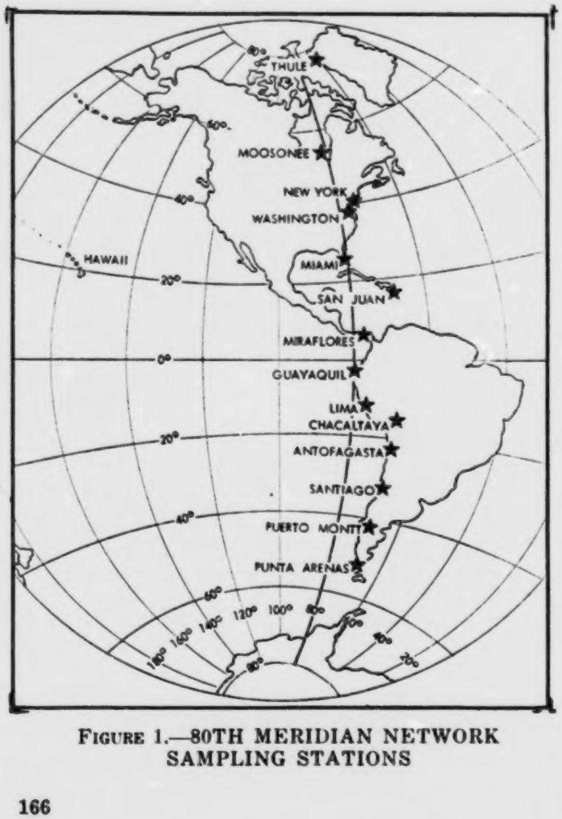

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, NOVEMBER 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m^3)		Gamma ratio $\left(\frac{\gamma > 1\ \text{Mev}}{\text{total}\ \gamma}\right)$
		Filter	Average for month	
Thule, Greenland	11/ 1-8	1.03		0.043
	11/ 8-15	0.472		0.047
	11/15-22	0.690		0.045
	11/22-12/1	1.045	0.808	0.043
Moosonee, Canada	11/1-8	0.368		0.045
	11/ 8-15	0.317		0.051
	11/15-22	0.482		0.053
	11/22-12/1	0.475	0.411	0.051
New York, N. Y.	11/ 1-8	0.966		0.052
	11/ 8-15	0.310		0.054
	11/15-22	0.895		0.053
	11/22-12/1	0.775	0.737	0.051
Washington, D. C.	11/ 1-8	0.714		0.051
	11/ 8-15	0.503		0.053
	11/15-22	1.30		0.052
	11/22-12/1	1.16	0.919	0.051
Miami, Florida	11/ 1-8	1.69		0.054
	11/ 8-15	0.870		0.052
	11/15-22	1.66		0.053
	11/22-12/1	0.915	1.28	0.044
Mauna Loa, Hawaii[a]	11/ 1-8	0.353		0.052
	11/ 8-15	0.538		0.052
	11/15-22	0.241		0.046
	11/22-12/1	0.377	0.377	0.051
San Juan, P. R.	11/ 1-8	0.423		0.050
	11/ 8-15	0.360		0.051
	11/15-22	0.386		0.042
	11/22-12/1	0.557	0.432	0.041
Miraflores, Canal Zone	11/ 1-8	0.0209		0.071
	11/ 8-15	0.0971		0.052
	11/15-22	0.203		0.056
	11/22-12/1	0.437	0.190	0.053
Guayaquil, Ecuador	11/ 1-8	0.0536		0.054
	11/ 8-15	0.0555		0.046
	11/15-22	0.0661		0.036
	11/22-12/1	0.0409	0.0540	0.044
Lima, Peru	11/ 1-8	0.133		0.064
	11/ 8-15	0.176		0.053
	11/15-22	0.162		0.030
	11/22-12/1	0.203	0.169	0.079
Chacaltaya, Bolivia	11/ 1-8	0.0515		0.037
	11/ 8-15	0.130		0.048
	11/15-22	0.0762		0.040
	11/22-12/1	0.0420	0.0749	0.046
Antofagasta, Chile	11/ 1-8	0.0692		0.066
	11/ 8-15	0.0853		0.065
	11/15-22	0.0754		0.049
	11/22-12/1	0.0754	0.0763	0.054
Santiago, Chile	11/ 1-8	0.0747		0.054
	11/ 8-15	0.0704		0.047
	11/15-22	0.0710		0.048
	11/22-12/1	0.0690	0.0713	0.046
Puerto Montt, Chile	11/ 1-8	0.0410		0.020
	11/ 8-15	0.0521		0.036
	11/15-22	0.0504		0.029
	11/22-12/1	0.0605	0.0510	0.050
Punta Arenas, Chile	11/ 1-8	0.0155		0.078
	11/ 8-15	0.0168		0.062
	11/15-22	0.0147		0.048
	11/22-12/1	0.0226	0.0174	0.015

[a] Mauna Loa data have been included for comparison with Chacaltaya, Bolivia. Both are high elevation stations (3400 and 5200 meters, respectively) and about equally distant north and south of the equator.

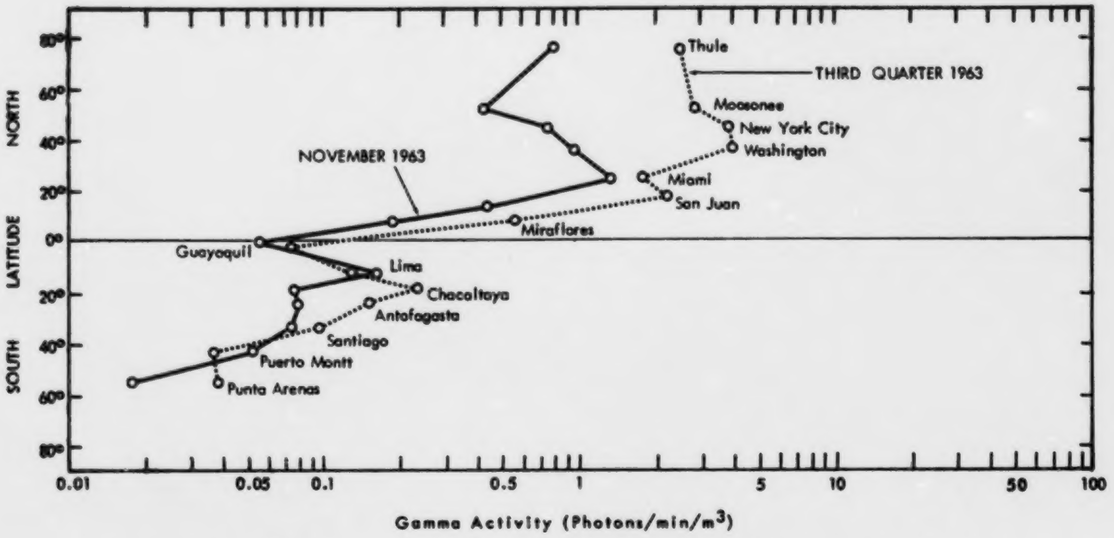

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, THIRD QUARTER, OCTOBER AND NOVEMBER 1963

those in the Southern Hemisphere with averages of 0.646 photons per minute per cubic meter (γ/min/m^3) and 0.0733 γ/min/m^3, respectively.

As in previous months the ratios of photons in excess of 1 Mev to total photons indicate the presence of larger concentrations of high-energy gamma emitters than would be expected in old fission product mixtures (*1*). Since June 1963, radiochemical and gamma spectrometric analyses have been in process to determine to what extent enrichment in high-energy activation products such as Y^{88} and Sb^{124} and fission products such as Ce^{144} and Ru^{106} is responsible for these discrepancies.

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Section II.—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, December 1963

Division of Radiological Health and Division of Environmental Engineering and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected

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twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error comprises nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations determined from the gamma spectrum.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error[a] (pc/liter)	Estimated concentration (pc/liter)	Error[a] (percent of concentration)
Iodine-131	0 to 100	± 10	100 or greater	± 10%
Barium-140	0 to 100	± 10	100 or greater	± 10%
Cesium-137	0 to 100	± 10	100 or greater	± 10%
Strontium-89	0 to 50	± 5	50 or greater	± 10%
Strontium-90	0 to 20	± 2	20 or greater	± 10%

[a] Two standard deviations.

Data Presentation

Table 2 presents summaries of the analyses for December 1963 (December 1-28, 1963). Although not shown in table 2, the iodine-131 and barium-140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero has been used as the best approximation to a nondetectable concentration of iodine-131 or barium-140. A similar procedure is used for the network average.

Figures 1, 2, and 3 are isogram maps showing the estimated strontium-89, strontium-90, and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 4. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, DECEMBER 1963*

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr⁹⁰ graph in *RHD* (1964)
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	
Ala:	Montgomery	1.22	1.24	1.5	1.5	5	<5	21	23	85	95	February
Alaska:	Palmer	1.20	1.14	1.6	1.6	15	10	31	27	180	160	March
Ariz:	Phoenix	1.16	1.15	1.7	1.6	<5	<5	3	3	30	25	January
Ark:	Little Rock	1.20	1.20	1.5	1.5	10	5	40	42	130	140	March
Calif:	Sacramento	1.22	1.24	1.6	1.6	<5	<5	8	8	60	60	April
	San Francisco	1.22	1.19	1.6	1.5	5	5	9	11	70	75	February
C. Z:	Cristobal	1.13	1.13	1.5	1.5	<5	<5	5	6	40	45	March
Colo:	Denver	1.19	1.20	1.6	1.6	15	10	17	16	85	85	April
Conn:	Hartford	1.19	1.16	1.6	1.6	10	<5	25	26	170	185	April
Del:	Wilmington	1.21	1.22	1.7	1.7	5	<5	23	22	130	145	January
D. C:	Washington	1.17	1.18	1.5	1.4	10	<5	17	18	80	90	February
Fla:	Tampa	1.22	1.25	1.4	1.4	5	<5	16	16	250	20[illegible]	January
Ga:	Atlanta	1.19	1.19	1.5	1.4	10	5	29	28	120	120	February
Hawaii:	Honolulu	1.15	1.19	1.7	1.6	10	<5	11	10	85	80	March
Idaho:	Idaho Falls	1.19	1.21	1.6	1.6	15	10	26	32	170	200	January
Ill:	Chicago	1.18	1.17	1.7	1.6	10	<5	20	21	110	130	February
Ind:	Indianapolis	1.25	1.28	1.6	1.6	10	<5	22	23	100	120	April
Iowa:	Des Moines	1.18	1.17	1.5	1.5	15	10	25	26	100	115	January
Kans:	Wichita	1.16	1.20	1.6	1.6	10	5	18	21	65	60	March
Ky:	Louisville	1.16	1.17	1.5	1.5	15	10	30	32	100	120	January
La:	New Orleans	1.24	1.22	1.5	1.4	15	5	44	47	135	125	March
Maine:	Portland	1.22	1.22	1.6	1.6	10	<5	35	34	235	230	January
Md:	Baltimore	1.14	1.17	1.4	1.4	10	5	20	21	105	130	January
Mass:	Boston	1.22	1.22	1.6	1.6	15	<5	36	35	250	260	February
Mich:	Detroit	1.20	1.18	1.6	1.6	5	<5	20	20	120	130	April
	Grand Rapids	1.23	1.22	1.6	1.6	5	<5	22	20	130	140	January
Minn:	Minneapolis	1.18	1.21	1.6	1.6	25	10	33	37	155	170	February
Miss:	Jackson	1.25	1.26	1.4	1.4	15	10	36	38	105	120	April
Mo:	Kansas City	1.17	1.16	1.5	1.5	15	10	29	27	85	95	April
	St. Louis	1.20	1.19	1.6	1.6	15	10	21	21	85	100	March
Mont:	Helena	1.20	1.21	1.6	1.6	10	5	29	28	195	210	March
Nebr:	Omaha	1.20	1.23	1.6	1.6	25	15	25	23	95	95	January
Nev:	Las Vegas	1.14	1.18	1.7	1.6	<5	<5	10	12	80	80	February
N. H:	Manchester	1.24	1.28	1.6	1.6	10	5	37	34	275	280	January
N. J:	Trenton	1.20	1.19	1.6	1.6	10	<5	19	19	120	130	April
N. Mex:	Albuquerque	1.16	1.17	1.6	1.6	<5	<5	11	12	50	50	March
N.Y:	Buffalo	1.18	1.16	1.7	1.6	10	<5	23	24	145	160	April
	New York	1.20	1.19	1.7	1.6	15	<5	30	28	175	195	February
	Syracuse	1.19	1.18	1.7	1.7	10	<5	22	22	150	170	March
N. C:	Charlotte	1.19	1.22	1.5	1.5	15	10	30	30	105	110	March
N. Dak:	Minot	1.18	1.20	1.6	1.6	40	20	55	60	145	165	January
Ohio:	Cincinnati	1.23	1.22	1.6	1.6	10	<5	23	24	90	110	April
	Cleveland	1.22	1.22	1.7	1.6	5	<5	22	23	105	120	March
Okla:	Oklahoma City	1.17	1.22	1.5	1.4	5	5	21	24	70	80	February
Ore:	Portland	1.21	1.20	1.6	1.6	20	10	30	26	180	155	April
Pa:	Philadelphia	1.22	1.22	1.6	1.6	5	<5	21	21	120	140	March
	Pittsburgh	1.27	1.35	1.6	1.6	10	<5	29	32	145	165	March
P. R:	San Juan	1.16	1.16	1.5	1.5	5	<5	12	12	65	70	March
R. I:	Providence	1.21	1.20	1.6	1.6	5	<5	27	27	175	190	January
S. C:	Charleston	1.21	1.20	1.5	1.4	10	5	27	28	120	115	April
S. Dak:	Rapid City	1.20	1.22	1.7	1.8	25	10	42	48	170	185	February
Tenn:	Chattanooga	1.23	1.22	1.5	1.4	15	10	35	38	120	130	February
	Memphis	1.22	1.23	1.5	1.5	10	5	28	29	75	80	January
Tex:	Austin	1.18	1.17	1.5	1.5	<5	<5	8	9	40	40	February
	Dallas	1.20	1.21	1.5	1.5	5	<5	19	20	75	90	April
Utah:	Salt Lake City	1.19	1.19	1.6	1.6	15	5	26	26	170	190	March
Vt.	Burlington	1.21	1.21	1.6	1.7	10	<5	28	28	200	220	April
Va:	Norfolk	1.17	1.17	1.5	1.5	10	5	21	20	90	95	April
Wash:	Seattle	1.21	1.20	1.6	1.6	15	5	24	17	155	115	February
	Spokane	1.21	1.17	1.7	1.6	20	5	31	30	160	165	April
W. Va:	Charleston	1.17	1.19	1.4	1.5	15	10	26	27	85	100	February
Wis:	Milwaukee	1.28	1.28	1.8	1.7	<5	<5	19	20	135	155	January
Wyo:	Laramie	1.18	1.19	1.6	1.5	15	10	20	17	115	110	January
Network average		1.20	1.20	1.6	1.6	11	5	24.2	24.6	123	130	

* The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, DECEMBER 1963

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5–5	46	<1–4	1	<10	63	<5–45	3	<10	63
10	15	5–9	3			50–95	16		
15	1	10–14	5			100–145	23		
20	1	15–19	6			150–195	14		
		20–24	19			200–245	5		
		25–29	14			250–295	2		
		30–34	7						
		35–39	4						
		40–60	4						
Total	63	Total	63	Total	63	Total	63	Total	63

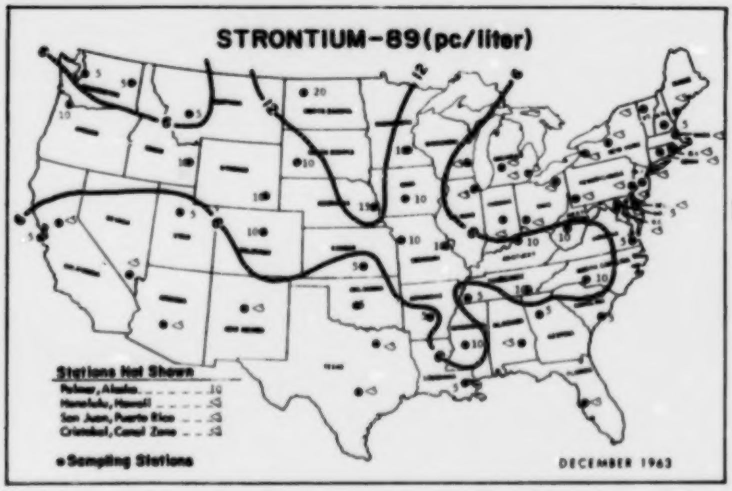
STRONTIUM-89 (pc/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii ...... <3
San Juan, Puerto Rico ... <3
Cristobal, Canal Zone ... <3
• Sampling Stations
DECEMBER 1963

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER, 1963

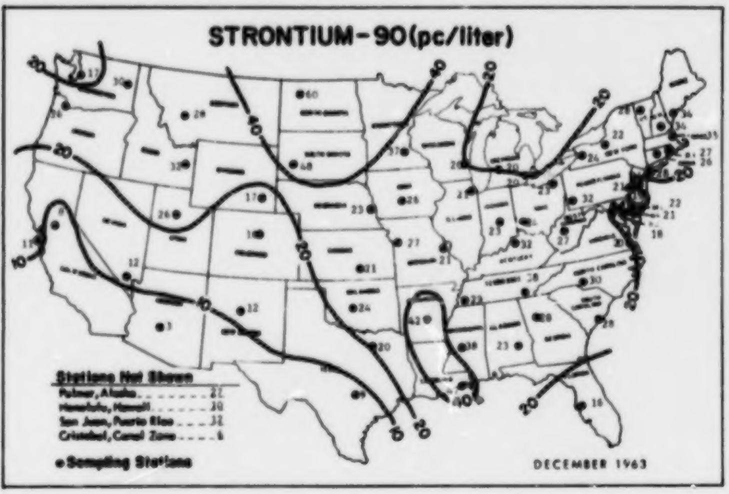
STRONTIUM-90 (pc/liter)
Stations Not Shown
Palmer, Alaska 21
Honolulu, Hawaii 30
San Juan, Puerto Rico ... 32
Cristobal, Canal Zone ... 6
• Sampling Stations
DECEMBER 1963

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER, 1963

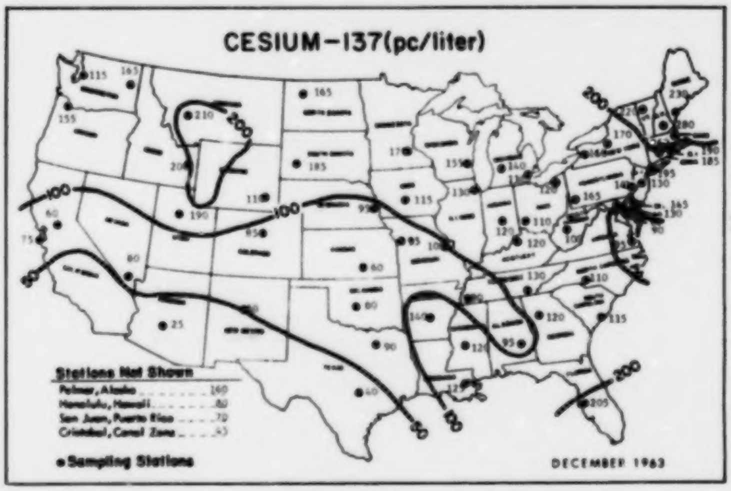
CESIUM-137 (pc/liter)
Stations Not Shown
Palmer, Alaska 160
Honolulu, Hawaii 80
San Juan, Puerto Rico ... 70
Cristobal, Canal Zone ... 45
• Sampling Stations
DECEMBER 1963

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, DECEMBER 1963

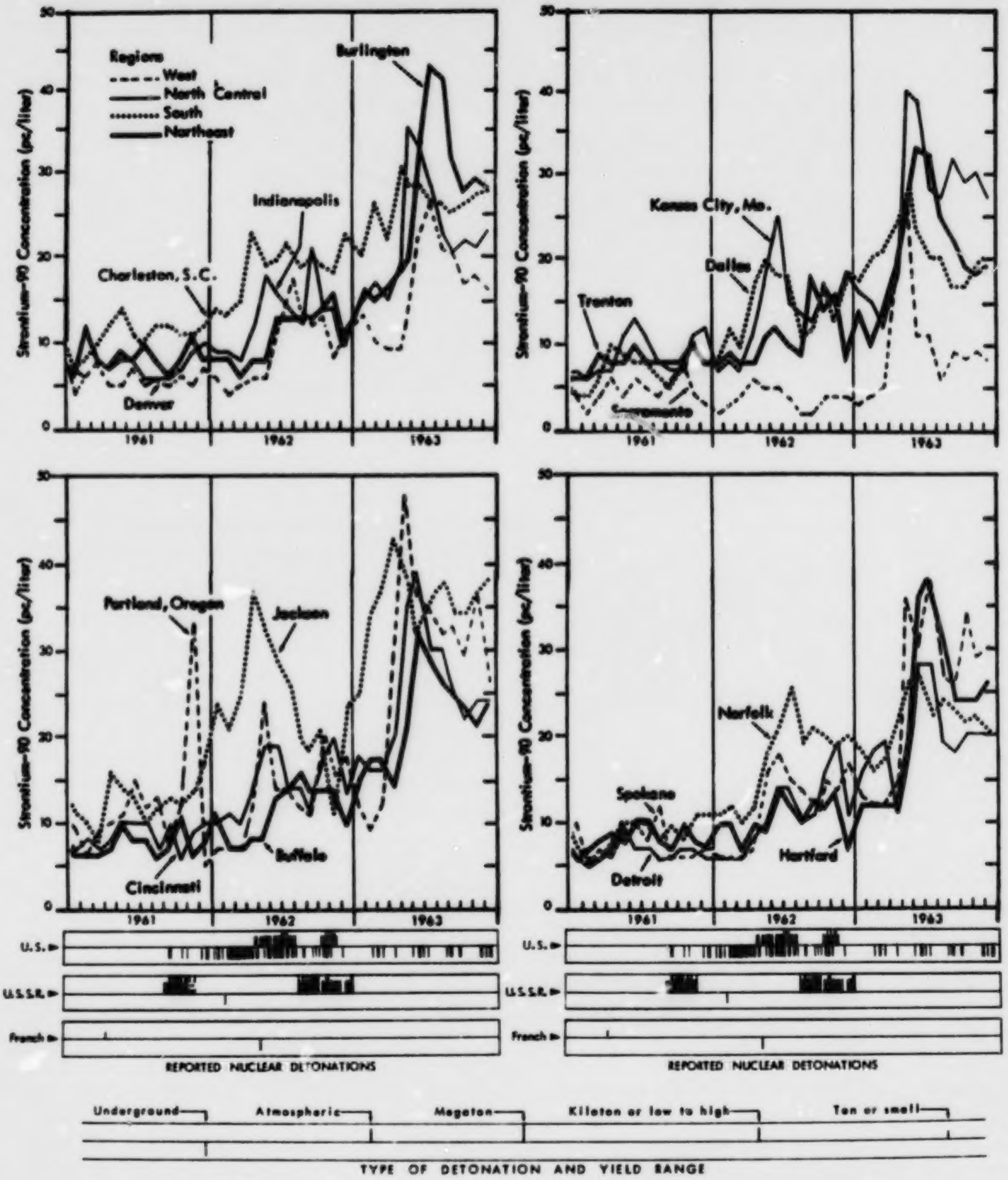

FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, 1961-DECEMBER 1963

2. Indiana Milk Network, December 1963

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

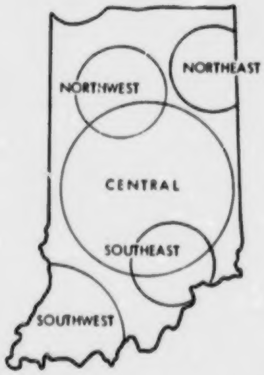

FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

The milk samples are routinely analyzed for iodine-131, cesium-137, barium-140, strontium-89 and strontium-90. Until August 1963, analyses for the gamma emitters iodine-131, cesium-137 and barium-140 were conducted on a weekly basis, except when iodine-131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium-89 and strontium-90 analyses are performed monthly for each station.

An ion exchange analytical procedure (*2*) is used for strontium-89 and strontium-90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine-131 cesium-137, and barium-140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values.

TABLE 4.—RADIONUCLIDES IN INDIANA MILK, DECEMBER 1963[a]

[Concentrations in pc/liter]

Sampling location	Sr^{89}	Sr^{90}	Cs^{137}	Ba^{140}
Northeast	10	13	120	0
Southeast	5	17	125	10
Central	0	14	110	0
Southwest	0	13	120	0
Northwest	5	14	130	0
State average	5	14	120	0

[a] The monthly average iodine-131 concentration at each station was zero.

3. Canadian Milk Network,[2] December 1963

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 6) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical

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[2] Data from *Radiation Protection Programs, Vol. 1, No. 1*:27-30, Radiation Protection Division, Canadian Department of National Health and Welfare (January 1964).

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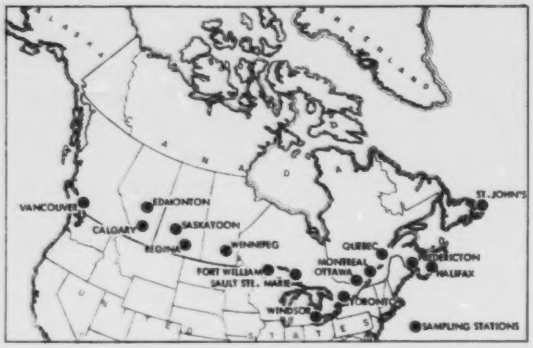

FIGURE 6.—CANADIAN MILK SAMPLING STATIONS

laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, strontium-89, cesium-137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*3*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine-131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting the yttrium-90 daughter nuclide while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotpe in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

TABLE 5.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK[a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	± 25%	± 20%	± 15%
Strontium-90	± 15%	± 10%	± 10%
Iodine-131	± 50%	± 20%	± 10%
Cesium-137	± 60%	± 25%	± 10%

[a] All errors are 2σ values, representing 95 percent confidence.

The overall errors, estimated on the basis indicated above, are given in table 5.

TABLE 6.—RADIONUCLIDES IN CANADIAN WHOLE MILK, DECEMBER 1963

[Radionuclide concentration in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-89	Strontium-90	Cesium-137
Calgary	0.94	1.5	12	52.6	292
Edmonton	1.38	1.6	3	37.5	283
Ft. William	1.28	1.6	13	49.1	283
Fredericton	1.32	1.6	6	57.0	358
Halifax	1.28	1.6	8	37.7	271
Montreal	1.23	1.7	11	38.7	275
Ottawa	1.23	1.6	5	33.1	229
Quebec	1.25	1.6	8	45.7	328
Regina	1.28	1.5	8	52.2	208
St. John's Nfld.	1.25	1.5	10	48.0	274
Saskatoon	1.29	1.6	15	48.2	210
Sault Ste. Marie	1.28	1.7	8	36.9	226
Toronto	1.28	1.6	4	17.7	136
Vancouver	1.33	1.6	7	32.5	272
Windsor	1.16	1.6	3	17.5	101
Winnipeg	1.24	1.7	7	43.1	221
Average	1.25	1.6	8	40.5	245

Results

Table 6 presents monthly averages of strontium-89, strontium-90, cesium-137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine-131 indicate that all samples had <5 pc/liter. Figure 7 shows the variation of the network average of the radionuclide concentration in Canadian whole milk.

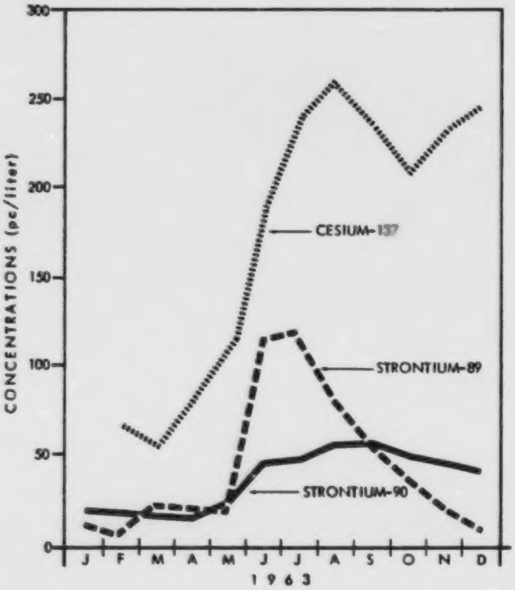

FIGURE 7.—NETWORK AVERAGE STRONTIUM-89, STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN CANADIAN WHOLE MILK

Discussion

It should be emphasized that the interpretation of fallout data in relation to health is a complex problem. In comparing the concentration levels in a particular medium with the Maximum Permissible Concentrations (MPC's) as established by the International Commission on Radiological Protection (*4*), it is necessary to keep in mind that the MPC values refer to conditions of continuous exposure over a lifetime. Therefore, the average levels over an extended period such as one year represent a better basis for comparison than do individual levels at any specific time.

4. Radiostrontium in Milk,[3] July-September 1963

Health and Safety Laboratory
U. S. Atomic Energy Commission

The Health and Safety Laboratory began monitoring liquid whole milk in New York City in 1954 for strontium-90 in order to estimate the dietary contribution of this radionuclide from milk. Subsequently, powdered milk monitoring was initiated at Perry, New York, in 1954 and at Mandan, North Dakota in 1955. Liquid whole milk monitoring was started in Honolulu, Hawaii, in August 1959.

The New York City sample is a monthly composite of pasteurized milk purchased daily in quart containers at retail stores. Five large dairies are represented in the sample. The Honolulu samples are monthly composites of quart samples of pasteurized milk collected weekly. Samples from two dairies are analyzed and the results are averaged. The Mandan and Perry samples are monthly composites of powdered milk collected in 5-pound lots from plants in each city. The Mandan sample is powdered buttermilk used in cattle feeds. Because of its protein and fat content, this buttermilk powder is used primarily as a milk replacer or feed supplement for calves. The Perry sample is powdered whole milk used for human consumption. The source of the Honolulu milk is from the island of Oahu where the

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[3] Data summarized from AEC's *Fallout Program Quarterly Summary Report, HASL-142*:173-80, Office of Technical Services, U. S. Department of Commerce, Washington, D. C. 20230 (January 1, 1964), price $4.00.

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TABLE 7.—STRONTIUM-90 AND CALCIUM IN MILK, JULY-SEPTEMBER 1963

Sampling station and period	Calcium (g/kg)	Strontium-90 (pc/kg)	Strontium-90 (pc/g Ca)
Liquid Milk			
New York City			
1963 Second Quarter			31.7
July	1.04	37.3	35.8
August	1.03	41.8	40.5
September	1.04	28.2	27.1
Honolulu, Hawaii			
1963 Second Quarter			9.0
July	1.10	9.8	9.0
August	1.08	8.3	7.6
September	1.12	8.3	7.4
Powdered Milk			
Perry, New York			
1963 Second Quarter			20.2
July	9.1	274	30.1
August	8.8	238	27.1
September	8.9	274	30.6
Powdered Buttermilk			
Mandan, North Dakota			
1963 Second Quarter			68.0
July	15.1	805	53.2
August	13.9	822	59.2
September	12.5	762	61.0

cows are on pasture throughout the year, and it is of interest to know how closely the strontium levels in milk in this area reflect changes in deposition rates.

The calcium and strontium-90 data are presented in table 7. The fluctuations of strontium-90 with time are shown in figures 8 and 9.

Comment

A marked increase in the strontium-90 content of milk from the continental U. S. stations was observed beginning in May 1963, due to the heavy spring fallout deposition. It is apparent from figures 8 and 9 that the peak strontium-90 concentrations were reached during the summer months.

The Honolulu milk samples still contain less strontium-90 per liter than those of other sampling stations, although there was a slight numerical increase in strontium-90 concentrations in the Honolulu samples in May also.

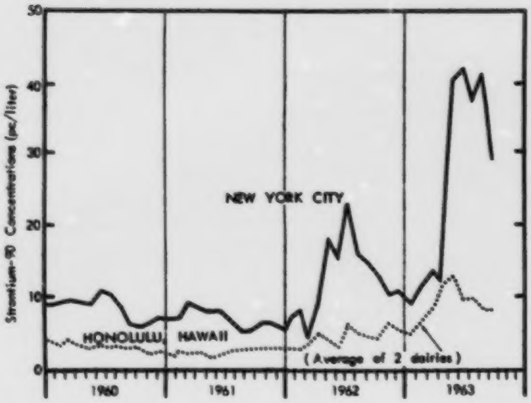
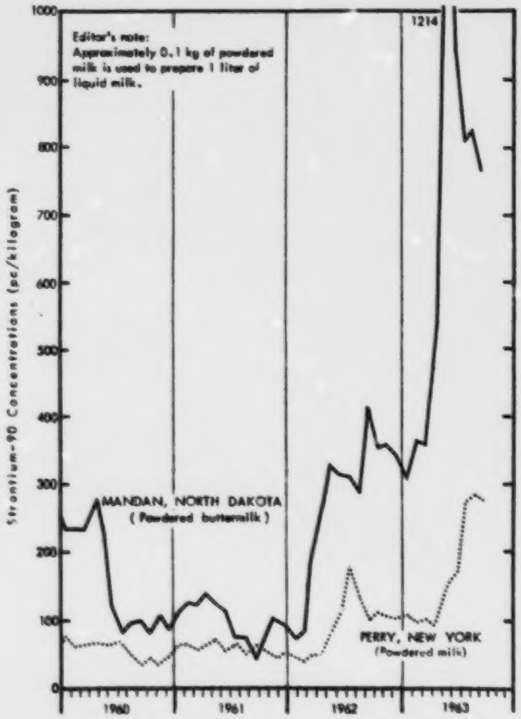


FIGURE 8.—STRONTIUM-90 IN LIQUID MILK SAMPLES



Editor's note:
Approximately 0.1 kg of powdered milk is used to prepare 1 liter of liquid milk.

FIGURE 9.—STRONTIUM-90 IN POWDERED MILK SAMPLES

REFERENCES

(1) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957-April 1963, *Radiological Health Data*, 4:511-23 (October 1963).

(2) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry*, *33*:1306-8 (September 1961).

(3) DasGupta, A. K., and H. G. Green: *A Method for Radiochemical Determination of Iodine-131 in Milk, RPD-23*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

(4) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

Recent coverage in *Radiological Health Data:*

Period	Issue
January-February 1962	*September 1962*
March-June 1962	*January 1963*
July-September 1962	*April 1963*
October 1962-March 1963	*October 1963*
April-June 1963	*January 1964*

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, JANUARY-DECEMBER 1963

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to assess the contribution of milk to an individual's or a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium-89, strontium-90, iodine-131 and cesium-137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all foods. The upper limits of intake Range II correspond to the Radiation Protection Guide (RPG) for iodine-131 and one-third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). However, the FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*). The ICRP has set the maximum permissible concentration (MPC) for cesium-137 in water for the population at large equal to 2000 pc/liter (*7*). This MPC may be applied to milk if it is assumed that all food would be contaminated to the same extent.

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged; (b) the averages for all weeks ending in twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data, 5*: 57 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data* 4:15-17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data, 4*:124-7 (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data, 3*:ii-iii (September 1962).

(*7*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

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[1] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

TABLE 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		December [a] 1962 November 1963	January [b] 1963 December 1963	December [a] 1962 November 1963	January [b] 1963 December 1963	December [a] 1962 November 1963	January [b] 1963 December 1963	December [a] 1962 November 1963	January [b] 1963 December 1963
Ala:	Montgomery	64	59	20	21	9	4	72	76
Alaska:	Palmer	33	30	19	21	8	5	108	117
Ariz:	Phoenix	14	12	4	4	6	4	22	22
Ark:	Little Rock	125	111	41	42	24	8	143	148
Calif:	Sacramento	39	38	9	10	7	6	55	58
	San Francisco	73	71	13	13	8	5	65	70
Colo:	Denver	26	26	16	16	7	6	81	83
Conn:	Hartford	23	21	21	23	5	4	133	143
Del:	Wilmington	30	28	24	25	8	4	115	121
D. C:	Washington	40	38	19	19	7	4	89	92
Fla:	Tampa	33	30	14	14	11	6	206	215
Ga:	Atlanta	89	83	28	29	14	5	131	137
Hawaii:	Honolulu	36	34	10	10	9	6	69	73
Idaho:	Idaho Falls	43	43	22	23	7	5	121	131
Ill:	Chicago	21	18	19	20	6	4	96	101
Ind:	Indianapolis	31	28	21	23	9	4	88	93
Iowa:	Des Moines	60	57	23	24	12	5	82	87
Kans:	Wichita	44	41	18	19	12	5	69	70
Ky:	Louisville	91	84	31	32	9	4	97	102
La:	New Orleans	141	135	40	42	19	8	142	147
Maine:	Portland	26	26	28	30	5	4	179	191
Md:	Baltimore	48	46	20	21	7	4	109	116
Mass:	Boston	32	31	31	33	5	4	192	206
Mich:	Detroit	17	16	19	20	6	4	101	105
	Grand Rapids	19	18	19	20	7	5	104	110
Minn:	Minneapolis	49	48	27	29	7	5	135	142
Miss:	Jackson	139	127	34	35	17	7	102	108
Mo:	Kansas City	73	65	25	26	16	4	74	78
	St. Louis	50	47	21	21	8	5	77	82
Mont:	Helena	48	46	25	26	14	5	149	160
Nebr:	Omaha	51	49	24	24	16	5	89	92
Nev:	Las Vegas	19	17	8	8	5	4	61	65
N. H:	Manchester	29	29	30	32	6	5	215	230
N. J:	Trenton	22	21	20	21	6	4	107	113
N. Mex:	Albuquerque	23	21	9	9	8	4	39	41
N.Y:	Buffalo	22	21	21	22	5	4	121	128
	New York	30	29	27	28	6	4	135	147
	Syracuse	25	24	22	23	5	4	113	122
N. C:	Charlotte	67	65	30	31	6	4	108	114
N. Dak:	Minot	81	82	44	47	5	5	123	130
Ohio:	Cincinnati	39	35	24	25	10	5	79	84
	Cleveland	25	23	20	21	7	4	95	100
Okla:	Oklahoma City	69	62	22	23	21	6	82	85
Ore:	Portland	83	71	27	28	9	4	143	150
Pa:	Philadelphia	28	26	22	23	7	4	108	115
	Pittsburgh	36	33	26	28	9	4	130	137
P. R:	San Juan	79	69	14	14	14	8	87	88
R. I:	Providence	26	26	25	26	6	4	142	151
S. C:	Charleston	69	63	26	26	13	6	114	118
S. Dak:	Rapid City	67	65	33	35	9	5	131	139
Tenn:	Chattanooga	110	100	35	36	10	4	127	133
	Memphis	96	87	30	31	14	5	81	84
Tex:	Austin	36	30	9	9	24	6	45	44
	Dallas	85	68	20	21	38	7	77	78
Utah:	Salt Lake City	34	33	20	22	8	6	135	145
Vt:	Burlington	27	25	25	27	4	4	149	161
Va:	Norfolk	47	45	22	22	7	4	94	97
Wash:	Seattle	59	56	24	24	8	5	141	145
	Spokane	50	49	24	25	7	5	125	132
W. Va:	Charleston	66	65	28	29	6	4	89	93
Wis:	Milwaukee	20	18	17	18	6	4	99	106
Wyo:	Laramie	40	38	20	21	5	4	113	115
Network average		50	47	22.7	23.7	10	5	108	114

[a] Annual averages were computed on basis of 53 weekly averages.
[b] Annual averages were computed on basis of 52 weekly averages.

RADIONUCLIDES IN DIETS FOR TEENAGERS, MAY 1962-NOVEMBER 1963

Division of Pharmacology, Food and Drug Administration

It has been estimated that among all age groups 16-19-year-old males need more food daily than any other segment of the U. S. population (*1*). Because of this, the Food and Drug Administration (FDA) chose this age group for a test of the maximum radionuclide intake of all population groups. As a basis for the test, the food plan used was that recommended by the U. S. Department of Agriculture (USDA) for a nutritionally adequate diet at moderate cost level for boys 16-19 years of age (*2*).

The FDA study of radionuclides in diets for teen-agers was begun on a pilot basis in May 1961 in the Washington, D. C. area. Since then, the program has been expanded to include 8 other cities—San Francisco, Minneapolis, St. Louis, Atlanta, Denver, Boston, Dallas, and Seattle.

By selecting the 16-19-year-old male, who daily needs 3,600 calories with adequate protein, minerals, and vitamins, compared with 3,200 calories and smaller amounts of nutrients needed by the "standard" man, the radionuclide intake in U. S. diets can be conservatively estimated. For the purposes of the sampling program, amounts of the foods selected from the 11 food groups of the USDA plan were proportioned according to the 1955 Household Food Consumption Survey (*3*).

PROCEDURES

To duplicate the diet of a 19-year-old male, a list of 82 different items of food and drink was prepared. Quarterly samples of these items, covering a two-week consumption period, were purchased from national food chain stores. Efforts were made to locate the sources of the food items and to arrange representatians in diet kitchens at each city in a manner basis as possible.

The food was prepared by professional dietitions in diet kitchens at each city in a manner comparable to domestic preparation procedures. The most acceptable home practices for washing, trimming, bone removal, and separation of wastes and cooking water were used. Meats, fish, and chicken were broiled before removing the bones. Some fruits and vegetables were prepared as raw servings while others were cooked. Canned foods and raw frozen fruits were used as is. Coffee and tea were brewed. Certain cereals, such as rice, oatmeal, and macaroni, were cooked in water. Representative portions of each food (including about 8 liters of drinking water) were homogenized into a slurry, and aliquots were analyzed for strontium-90 and cesium-137 at the nearest FDA District laboratory. A radiochemical technique followed by beta counting was employed for strontium-90 analysis and gamma spectroscopy was employed for cesium-137 analysis.

RESULTS

The quarterly strontium-90 and cesium-137 concentrations in the recommended diet are shown in tables 1 and 2 for each city sampled, as well as the quarterly average for all cities. Strontium-90 and cesium-137 results are plotted in figure 1.

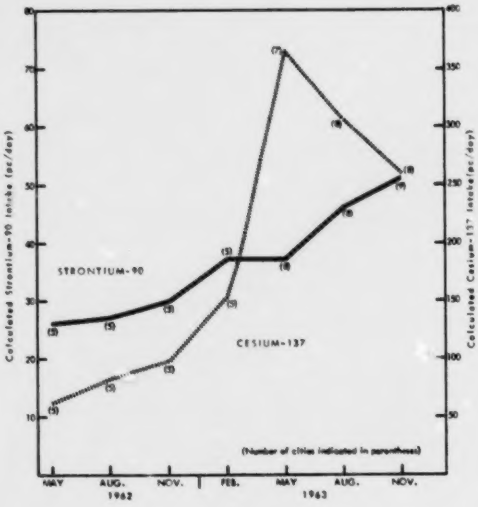

FIGURE 1.—AVERAGE STRONTIUM-90 AND CESIUM-137 CONCENTRATIONS IN TEEN-AGER TOTAL DIET

TABLE 1.—STRONTIUM-90 CONCENTRATIONS IN THE TOTAL DIET (Including Drinking Water), MAY 1962—NOVEMBER 1963

Sampling locations		May 1962		August 1962		November 1962		February 1963		May 1963		August 1963		November 1963	
		pc/kg	pc/day[a]	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day
Calif:	San Francisco	3.0	11	3.4	13	4.8	18	8.0	30	9.4	35	5.7	21	6.4	24
Colo:	Denver	[b]								7.5	28	7.5	28	10	38
D. C:	Washington	6.4	24	6.9	26	8.4	32	12	45	11	41	11	41	13	49
Ga:	Atlanta	9.7	36	7.2	27	9.2	35	13	49	10	38	18	68	19	71
Mass:	Boston													13	49
Minn:	Minneapolis	5.2	20	9.0	34	7.9	30	8.8	33	10	38	18	68	15	56
Mo:	St. Louis	10	38	8.8	33	9.5	36	7.1	27	8.5	32	17	64	16	60
Texas:	Dallas									13	49	10	38	13	49
Wash:	Seattle									10	38	10	38	16	60
Average		6.9	26	7.1	27	7.9	30	9.8	37	9.9	37	12.2	46	13.5	51

[a] Intakes are calculated using a consumption factor of 3.76 kg/day for the 16–19-year-old male (*3*).
[b] Blank indicates no sample collected.

Strontium-90

The calculated average strontium-90 intake in the diet can be seen from table 1 to have increased steadily from 26 pc/day in May 1962 to 51 pc/day for November 1963. The latter value represents about one-fourth of the top of Range II (200 pc/day) of transient rates of daily intake for strontium-90 as recommended by the Federal Radiation Council (*4*).

Cesium-137

Table 2 shows that the calculated average cesium-137 intake in the diet increased from 62 pc/day in May 1962 to a peak of 366 pc/day in May 1963 and then decreased to 306 pc/day in August 1963 and 260 pc/day in November 1963. The Federal Radiation Council has not issued guidance for daily cesium-137 intake, since existing protection guides were deemed to be appropriate (*5*). If the 168-hour maximum permissible concentration in water for cesium-137 given by the National Committee on Radiation Protection in National Bureau of Standards Handbook 69 (*6*) is divided by 100 and a daily intake of two liters of water is assumed, a general population cesium-137 intake guide of about 4000 pc/day can be calculated. The value of 366 pc/day represents less than one-tenth of this calculated cesium-137 intake guide.

REFERENCES

(*1*) The National Academy of Sciences—National Research Council: *Recommended Dietary Allowances*, National Research Council Publication 589, Revised (1958).

(*2*) U. S. Department of Agriculture: *Family Food Plans and Food Costs, Home Economics Research Report No. 20*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (November 1962), price 35 cents.

(*3*) U. S. Department of Agriculture: *Food Consumption of Households in the United States, Report No. 1 (1955)*, Household Food Consumption Survey, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (December 1956), price $1.25.

TABLE 2.—CESIUM-137 CONCENTRATIONS IN THE TOTAL DIET (Including Drinking Water), MAY 1962—NOVEMBER 1963

Sampling locations		May 1962		August 1962		November 1962		February 1963		May 1963		August 1963		November 1963	
		pc/kg	pc/day[a]	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day	pc/kg	pc/day
Calif:	San Francisco	1.0	3.8	14	53	9.0	34	16	60	76	286	42	158	57	214
Colo:	Denver	[b]								79	297	94	354	57	214
D. C:	Washington	12	45	39	142	37	139	51	192	73	272	74	278	55	207
Ga:	Atlanta	29	109	16	60	23	86	46	173	128	481	78	293	63	237
Mass:	Boston													99	372
Minn:	Minneapolis	13	49	31	112	28	105	62	223	114	427	109	410	83	312
Mo:	St. Louis	33	124	13	49	34	128	31	112			80	300		
Texas:	Dallas									100	376	68	256	44	165
Wash:	Seattle									113	425	106	398	95	357
Average		17.6	62	23	83	26.2	98	41	152	98	366	81	306	69	260

[a] Intakes are calculated using a consumption factor of 3.76 kg/day for the 16–19-year-old male (*3*).
[b] Blank indicates no sample collected.

(4) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(5) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, pp. 4402-3 (May 18, 1960).

(6) National Committee on Radiation Protection: *Maximum Permissible Body Burdens and Maximum Permissible Concentrations of Radionuclides in Air and in Water for Occupational Exposure, National Bureau of Standards Handbook 69*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (June 5, 1959), Price 35 cents.

Previous coverage in *RHD:*

Period	Issue
May 1961-August 1962	*January 1963*
May 1962-February 1963	*June 1963*

Section III.—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, OCTOBER 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System (formerly National Water Quality Network) since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 128 stations as of March 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1-6*).

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Public Health Service laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until January 1960, when the levels became essentially equal to background. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. (Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.) On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit early detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once a month except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted at the Cincinnati Laboratory within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

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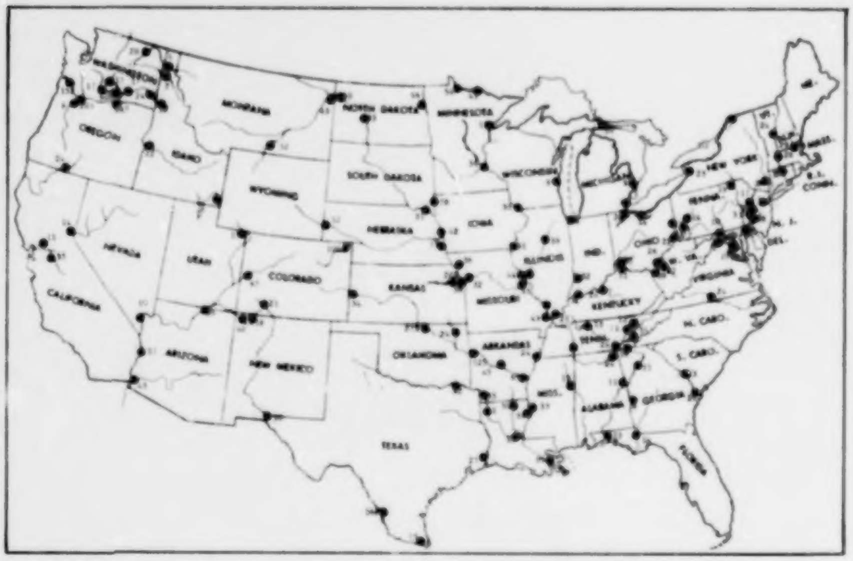

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, OCTOBER 1963

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning November 1962 the frequency of strontium-90 analyses was reduced to twice a year at each sampling point except those stations immediately below nuclear installations. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the above reference (*7*). Tributyl phosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Beginning with the first quarter of 1962, a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Results

Table 1 presents October 1963 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples, as well as some analyses incomplete at the time of this report, will be included in the System's Annual Compilation of Data (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter, with the exception that when all samples have zero pc/liter the mean is reported as zero. When the

TABLE 1.—RADIOACTIVITY IN SURFACE WATERS, OCTOBER 1963

[Average concentrations in pc/liter]

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsburgh, Pa	2	12	11	0	1	1
Animas River:						
Cedar Hill, N. Mex	5	13	18	0	3	3
Apalachicola River:						
Chattahoochee, Fla	5	9	14	0	0	0
Arkansas River:						
Coolidge, Kansas	3	31	34	0	33	33
Ponca City, Okla	239	34	273	7	0	7
Fort Smith, Ark	69	56	125	6	3	9
Little Rock, Ark	13	32	45	2	1	3
Pendleton Ferry, Ark	24	41	65	1	5	6
Big Horn River:						
Hardin, Mont	16	36	52	2	8	10
Big Sioux River:						
Sioux Falls, S. Dak	19	59	78	1	3	4
Chattahoochee River:						
Atlanta, Ga	3	8	11	0	0	0
Columbus, Ga	1	8	9	0	0	0
Lanett, Ala	3	8	11	0	0	0
Chena Slough:						
Fairbanks, Alaska	1	5	6	0	0	0
Clearwater River:						
Lewiston, Idaho	7	11	18	0	0	0
Clinch River:						
Clinton, Tenn	2	10	12	0	<1	<1
Kingston, Tenn	29	42	71	<1	0	<1
Colorado River:						
Loma, Colo	56	41	97	11	12	23
Page, Ariz	2	37	39	0	7	7
Boulder City, Nev	0	19	19	0	7	7
Parker Dam, Calif-Ariz	2	15	17	0	10	10
Yuma, Ariz	0	43	43	0	7	7
Columbia River:						
Northport, Wash	5	15	20	0	1	1
Wenatchee, Wash	0	17	17	0	0	0
Pasco, Wash	132	770	902	0	0	0
McNary Dam, Ore	37	430	467	0	1	1
Bonneville, Ore	11	194	205	0	0	0
Clatskanie, Ore	14	138	152	0	<1	<1
Cumberland River:						
Clarksville, Tenn	2	11	13	0	0	0
Connecticut River:						
Wilder, Vt	7	17	24	0	0	0
Northfield, Mass	7	19	26	0	0	0
Enfield Dam, Conn	21	12	33	0	0	0
Cuyahoga River:						
Cleveland, Ohio	3	41	44	1	5	6
Delaware River:						
Martins Creek, Pa	2	15	17	0	0	0
Trenton, N. J	2	12	14	0	1	1
Philadelphia, Pa	17	16	33	1	0	1
Escambia River:						
Century, Fla	3	10	13	0	0	0
Great Lakes:						
Duluth, Minn	2	9	11	0	0	0
Sault Ste. Marie, Mich	0	10	10	0	1	0
Gary, Ind	4	5	9	0	1	1
Port Huron, Mich	1	8	9	0	0	0
Detroit, Mich	0	7	7	0	0	0
Buffalo, N. Y	9	14	23	1	0	1
Milwaukee, Wis	2	7	9	0	0	0
Green River:						
Dutch John, Utah	1	16	17	0	0	0
Hudson River:						
Poughkeepsie, N. Y	3	26	29	0	1	1
Illinois River:						
Peoria, Ill	7	32	39	1	2	3
Grafton, Ill	13	31	44	1	2	3
Kanawha River:						
Winfield Dam, W. Va	4	18	22	0	0	0
Klamath River:						
Keno, Ore	5	19	24	0	0	0
Kansas River:						
De Soto, Kans	158	45	203	9	2	11
Maumee River:						
Toledo, Ohio	5	21	26	1	0	1
Little Miami River:						
Cincinnati, Ohio	14	16	30	0	1	1
Merrimack River:						
Lowell, Mass	11	18	29	1	0	1
Mississippi River:						
St. Paul, Minn	7	29	36	0	4	4
Dubuque, Iowa	6	24	30	0	1	1
Burlington, Iowa	4	27	31	0	2	2
E. St. Louis, Ill	17	24	41	1	1	2
Cape Girardeau, Mo	17	32	49	2	2	4
W. Memphis, Ark	2	22	24	0	2	2
Vicksburg, Miss	8	25	33	1	3	4
Delta, La	8	26	34	1	2	3
New Orleans, La	1	37	38	0	2	2
Missouri River:						
Williston, N. Dak	8	42	50	0	7	7
Bismarck, N. Dak	4	29	33	1	6	7
Yankton, S. Dak	4	27	31	0	3	3
Omaha, Nebr	16	26	42	3	7	10
St. Joseph, Mo	18	18	36	3	2	5
Kansas City, Kans	17	21	38	4	3	7
Missouri River—Cont.						
Missouri City, Mo	10	22	32	1	2	3
St. Louis, Mo	23	22	45	3	2	5
Monongahela River:						
Pittsburgh, Pa	0	17	17	0	1	1
North Platte River:						
Henry, Nebr	11	42	53	<1	25	26
Ohio River:						
Addison, Ohio	4	22	26	1	0	1
Huntington, W. Va	2	16	18	0	0	0
Cincinnati, Ohio	0	11	11	0	2	2
Louisville, Ky	0	24	24	0	0	0
Evansville, Ind	6	28	34	1	1	2
Cairo, Ill	0	21	21	1	0	1
Toronto, Ohio	2	20	22	1	0	1
Ouachita River:						
Bastrop, La	7	43	50	0	3	3
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	4	4	0	1	1
Platte River:						
Plattsmouth, Nebr	40	37	77	3	5	8
Potomac River:						
Williamsport, Md	1	17	18	0	0	0
Great Falls, Md	2	13	15	0	1	1
Washington, D. C	4	15	19	1	1	2
Rainy River:						
Baudette, Minn	11	43	54	0	1	1
International Falls, Minn	9	32	41	0	0	0
Red River, North:						
Grand Forks, N. Dak	8	51	59	0	2	2
Red River, South:						
Denison, Tex	3	59	62	0	0	0
Index, Ark	5	50	55	0	3	3
Bossier City, La	1	0	1	0	0	0
Alexandria, La	5	25	30	1	4	5
Rio Grande River:						
Alamosa, Colo	6	15	21	1	3	4
El Paso, Tex	3	27	30	0	7	7
Laredo, Tex	137	31	168	14	5	19
Brownsville, Tex	37	38	75	4	2	6
Roanoke River:						
John H. Kerr Resr/Dam, Va	4	20	24	0	0	0
Sabine River:						
Ruliff, Tex	10	17	27	1	0	1
Sacramento River:						
Courtland, Calif	3	8	11	0	0	0
San Joaquin River:						
Vernalis, Calif	11	24	35	2	3	5
San Juan River:						
Shiprock, N. Mex	13	27	40	13	18	21
St. Lawrence River:						
Massena, N. Y	5	12	17	0	0	0
Schuylkill River:						
Philadelphia, Pa	2	36	38	0	0	0
Savannah River:						
North Augusta, S. C	3	10	13	0	0	0
Port Wentworth, Ga	5	19	24	0	0	0
Shenandoah River:						
Berryville, Va	2	0	2	0	1	1
Ship Creek:						
Anchorage, Alaska	3	2	5	0	0	0
Snake River:						
Ice Harbor Dam, Wash	6	18	24	0	2	2
Wawawai, Wash	0	17	17	0	2	2
Payette, Idaho	6	16	22	1	5	6
South Platte River:						
Julesburg, Colo	28	72	100	4	33	37
Spokane River:						
Post Falls, Idaho	0	7	7	0	0	0
Susquehanna River:						
Sayre, Pa	4	15	19	0	0	0
Conowingo, Md	6	21	27	0	0	0
Tennessee River:						
Lenoir City, Tenn	5	9	14	0	1	1
Chattanooga, Tenn	2	14	16	<1	0	<1
Bridgeport, Ala	5	19	24	0	0	0
Pickwick Landing, Tenn	3	21	24	0	0	0
Tombigbee River:						
Columbus, Miss	7	8	15	1	0	1
Truckee River:						
Farad, Calif	2	12	14	0	0	0
Verdigris River:						
Nowata, Okla	0	24	24	0	0	0
Wabash River:						
New Harmony, Ind	20	12	32	2	1	3
Willamette River:						
Portland, Ore	0	6	6	0	0	0
Yakima River:						
Richland, Wash	2	15	17	0	2	2
Yellowstone River:						
Sidney, Mont	26	37	63	5	4	9
Maximum	239	770	902	14	33	37
Minimum	0	0	1	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (*6*).

calculated mean is between zero and 0.5 the mean is reported as < 1 pc/liter. The most recent quarterly strontium-90 results appeared in the January 1964 *RHD* (*9*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the October 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957-1962 have been summarized by Weaver *et al* (*10*).

Discussion

On the Columbia River, the monthly dissolved beta activity averages were greater than 200 pc/liter. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 152 and 902 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*12*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663*, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Prince $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

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(*8*) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).

(*9*) Public Health Service: National Water Quality Network, July 1963, *Radiological Health Data, 5*: 31-35, (January 1964).

(*10*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957-1962, *Radiological Health Data, 4*:306-16, (June 1963).

(*11*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association 53*:704 (June 1961).

(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

RADIOSTRONTIUM IN TAP WATER, MAY-OCTOBER 1963[1]

Health and Safety Laboratory
U. S. Atomic Energy Commission

The Health and Safety Laboratory has performed analyses for strontium-90 in tap water at New York City since August 1954. At Richmond, California, the sampling of tap water was begun in April 1958 and continued through June 1963. Samples of tap water are collected daily at each site so that by the end of the month a composite of at least 100 liters is available for analysis. Also, determinations of strontium-89 have been made since September 1961. The analytical methods are given in the Health and Safety Laboratory Manual of Standard Procedures (*1*).

Data for the past several years are plotted in figure 1. Data prior to 1958 appear in an earlier HASL report (*2*). Strontium-90 concentrations and strontium-89/strontium-90 ratios for May through October 1963 appear in table 1.

---

[1] Data taken from AEC Fallout Program Quarterly Summary Report, *HASL-142*:173-80, Office of Technical Services, U. S. Department of Commerce, Washington, D. C. 20230 (January 1, 1964), price $4.00.

Monthly average strontium-90 concentrations in tap water at New York City increased to 2.14 pc/liter in July 1963. Thereafter the trend was one of decreasing levels. Although the levels at Richmond, California are normally lower than those observed in New York City, the data for Richmond show that levels there were also increasing during the spring of 1963.

The strontium-89/strontium-90 ratios indicate that the fallout was probably not of any more recent origin when strontium-90 concentrations were high than when they were low.

The maximum strontium-90 concentrations observed are below the acceptable limit of 10 pc/liter as set forth in the interstate carrier drinking water standards (*3*).

TABLE 1.—RADIOSTRONTIUM IN TAP WATER

Month 1963	New York City[a]		Richmond, California[b]	
	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}	Sr^{90} (pc/liter)	Sr^{89}/Sr^{90}
May	1.23	3.9	0.50	3.8
June	1.23	3.3	0.82	1.9
July	2.14	2.2	[d]	[d]
August	1.76	[c]		
September	1.88	[c]		
October	1.40	[c]		

Note: Strontium-89 extrapolated to midpoint of sampling period.
[a] From 100–200 liters per sample.
[b] Approximately 100 liters per sample.
[c] Strontium-89 analyses not performed.
[d] Sampling discontinued.

REFERENCES

(*1*) U. S. Atomic Energy Commission: *Manual of Standard Procedures*, *40*:E-38-01-16, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York 14, N. Y.

(*2*) U. S. Atomic Energy Commission: *Environmental Contamination from Weapons Tests, HASL-42*, Office

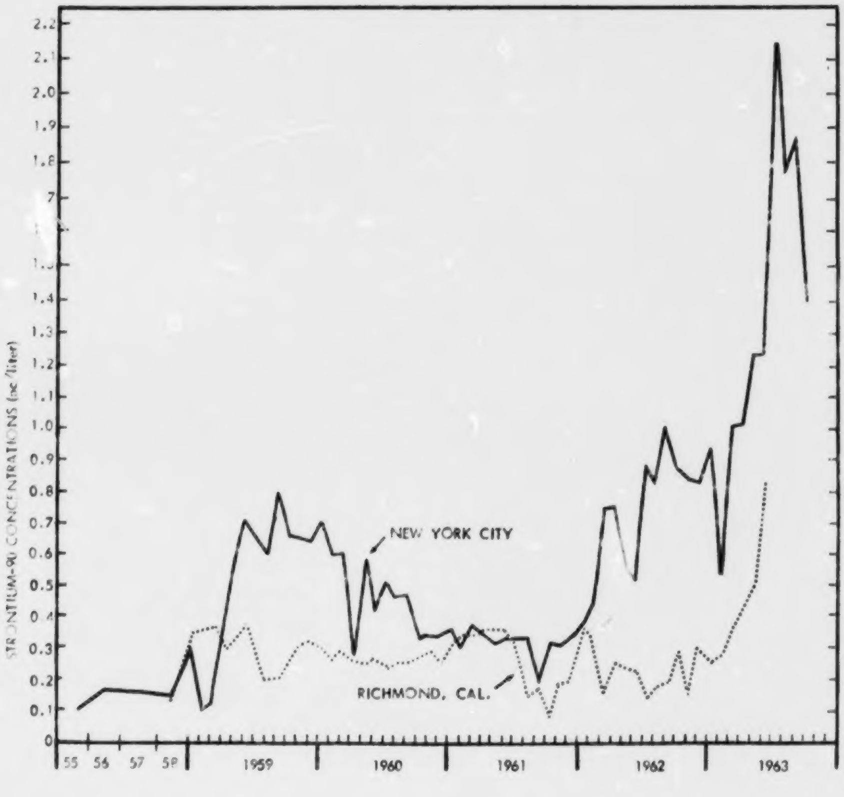

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN TAP WATER

of Technical Services, Department of Commerce, Washington, D. C. 20230, (October 1962), price $3.50.

(*3*) Federal Register Rules and Regulations: *Title 42—Public Health, Chapter 1*—Public Health Service, Department of Health, Education, and Welfare; Part 72, *Interstate Quarantine, Subpart J, Drinking Water Standards, 27*:2154-5, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (March 6, 1962).

Recent coverage in *Radiological Health Data:*

Period	Issue
Third and fourth quarters 1961	*June 1962*
January-April 1962	*September 1962*
March-June 1962	*January 1963*
July-December 1962	*July 1963*
January-April 1963	*January 1964*

Section IV.—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors quarterly reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 22 AEC installations have appeared periodically in *Radiological Health Data* since November 1960. Summaries follow for Bettis Atomic Power Laboratory and Mound Laboratory.

Releases of radioactive materials from these Laboratories for the periods covered in the reports below are regulated in accordance with standards set forth in the Federal Register Title 10 - Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—MAXIMUM PERMISSIBLE CONCENTRATIONS PERTAINING TO ENVIRONMENTAL MONITORING AT BETTIS ATOMIC POWER LABORATORY AND MOUND LABORATORY[a]

Radionuclide	Air (pc/m³)	Water (pc/liter)
Hydrogen-3 (tritium)	200,000	3,000,000
Strontium-90	10	100
Polonium-210	20	700
Uranium-natural	2	20,000
Plutonium-239	0.06	5,000

[a] The concentration standards given here were abstracted from the Atomic Energy Commission's regulation 10 CFR Part 20 (Federal Register, November 17, 1960).

1. Bettis Atomic Power Laboratory, July 1962-June 1963[1]

Westinghouse Electric Corporation

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and the central station atomic power reactor at Shippingport, Pennsylvania.

Effective July 1962, several changes were made in BAPL's environmental monitoring program as described below. The data for the 12-month period from July 1962 through June 1963 are given in table 2. Figure 1 shows the location of sampling sites for the revised program.

Liquid Radioactive Waste: The liquid effluent discharged from the Laboratory is sampled continuously and composite samples are analyzed weekly for gross alpha and gross beta-gamma activity and quarterly for strontium-90 beta activity, as in the past. In addition, an analysis for total uranium alpha activity will

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[1] Data and information summarized from semi-annual reports to the Pennsylvania Department of Health entitled *Environmental Radioactivity at the Bettis Atomic Power Laboratory*: PNRO-DEV-122, July 12, 1962; PNRO-DEV-124, January 11, 1963; and PNRO-DEV-126, July 15, 1963. The reports were prepared by BAPL's Industrial Hygiene Department and transmitted through the AEC Pittsburgh Naval Reactors Office.

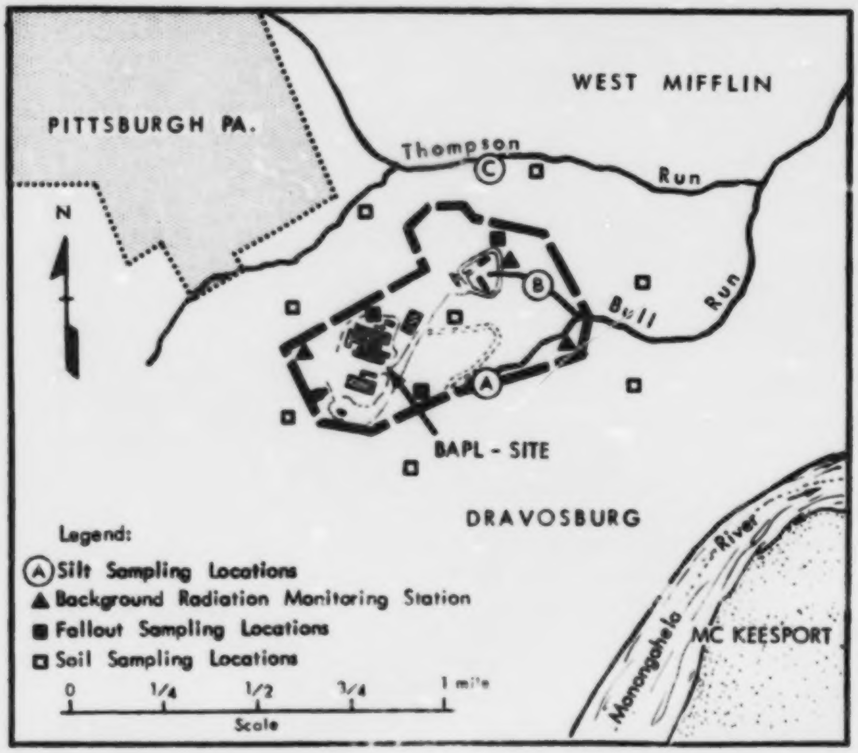
WEST MIFFLIN
PITTSBURGH PA.
Thompson
Run
N
Bull
Run
BAPL - SITE
DRAVOSBURG
Monongahela River
MC KEESPORT
Legend:
Ⓐ Silt Sampling Locations
▲ Background Radiation Monitoring Station
■ Fallout Sampling Locations
□ Soil Sampling Locations
0
1/4
1/2
3/4
1 mile
Scale
A
B
C

FIGURE 1.—BETTIS ATOMIC POWER LABORATORY SAMPLING STATIONS

be performed whenever the combined gross alpha and gross beta-gamma activities exceed 2×10^{-6} μc/cc.

Background Monitoring Stations: Four background monitoring stations (previously one) are in continuous operation on the Laboratory property. Three of the stations are located at the perimeter of the Laboratory and one station is centrally-located with respect to the main Laboratory area. These stations continually measure and record the external beta-gamma radiation level, the external gamma radiation level and the beta-gamma activity of particulates in air as collected by a continuous air monitor of the moving filter type. An air sample is continuously collected at two of the stations. The filters removed from the high volume air samplers are retained for specific analysis when required to identify the nature of the airborne activity. External gamma dose rates for the three perimeter stations are given in table 2.

TABLE 2.—RADIOACTIVITY IN THE BAPL ENVIRONMENT

Type of measurement	1962		1963	
	3rd Quarter	4th Quarter	1st Quarter	2nd Quarter
Liquid wastes (pc/liter)				
Gross activity[a]	108	102	170	400
Strontium-90	1.1	5.2	7.1	[b]—
Beta-gamma dose rate (mrad/hr)		[c]0.027		[c]0.024
Beta activity in fallout (mc/mi² mo)	128	130	76	210
Stream silt (pc/gm)				
Alpha: Station A	87	19	24	36
Station B	64	16	39	26
Station C	no sample	16	17	13
Beta: Station A	33	31	13	91
Station B	16	17	16	42
Station C	no sample	11	10	15

[a] An environmental MPC of 2000 pc/liter is used as the standard for liquid wastes effluent (see table 1).
[b] Second quarter 1963 strontium 90 analysis. The second quarter 1962 average was 1.0 pc/liter.
[c] Beta-gamma dose rate values are semi-annual averages.

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Soil Samples: Soil Samples are collected at eight locations (previously eleven) on and off site and are retained for a period of two years. These samples will be analyzed for radioactivity only on an "as required" basis. No analyses were required during the 12-month period ending June 1963.

Stream Silt: Stream silt samples are collected quarterly at three locations (previously four) described as follows:

Location A: Bull Run downstream from the point where the water effluent leaves the main laboratory area at the first point where silt has accumulated.

Location B: C-Area effluent downstream from its origin at the first point where silt has accumulated.

Location C: Thompson Run downstream from the junction of the High Temperature Test Facility effluent and Thompson Run at the first point where silt has accumulated.

These samples are analyzed quarterly for gross alpha activity and gross beta-gamma activity. Table 2 shows that samples from location A tend to have slightly higher beta activity than B or C and both A and B tend to have higher alpha activities than C.

Fallout: Fallout samples are collected at three locations (previously eight) at the perimeter of the Laboratory. The samples are collected over a period of one month in high-wall stainless steel pots and are analyzed for gross alpha activity and gross beta-gamma activity.

Recent coverage in *RHD:*

Period	Issue
January to June 1961	*April 1962*
July 1961 to June 1962	*April 1963*

2. Mound Laboratory, July 1962-June 1963

Monsanto Research Corporation

Of the radionuclides in use at Mound Laboratory, only polonium-210, plutonium-239, and hydrogen-3 (tritium) are potential environmental contaminants. No measurable amounts of penetrating radiation such as gamma or hard beta have contributed to the environmental contamination by the Laboratory during the period covered by this report.

The environmental monitoring program, conducted by the Monsanto Research Corporation is planned and coordinated with regard to all of the various projects performed in the Laboratory. Water and air monitoring methods and results are discussed below.

Air Monitoring

A continuous air monitor for measurement of tritium and particulate air sampling equipment for measurement of alpha activity are mounted on a one-ton panel truck for use in the routine monitoring of the environmental air at 95 locations selected within a radius of 20 miles. The choice of sites on a given day depends on the wind direction at the time of collection.

During the 12-month period ending June 1963, 448 samples were taken for determination of tritium in air. In all cases tritium was nondetectable.

Monitoring for possible polonium-210 and plutonium-239 released to the environment is accomplished by determination of long-lived gross alpha on filter paper samples. Counting is done in a low-background proportional counter after sufficient time elapses after collection to permit the decay of short-lived daughter products of radon and thoron. The measured concentrations of alpha activity in air are summarized in table 3. No specific determinations of polonium-210 or plutonium-239 were made, since the alpha activity remained substantially below the environmental MPC's for these nuclides (see table 1). It may be observed that the largest difference between upwind and downwind average alpha activity

TABLE 3.—LONG LIVED ALPHA CONCENTRATIONS IN AIR IN THE MOUND LABORATORY ENVIRONMENT

[Average concentrations in pc/m³]

Direction from laboratory relative to wind	Third quarter 1962		Fourth quarter 1962		First half 1963	
	No. of samples	Alpha	No. of samples	Alpha	No. of samples	Alpha
Upwind	18	0.0014	18	0.0011	26	0.0034
Downwind	131	0.0029	115	0.0019	154	0.0030

is 0.0015 pc/m^3 for third quarter 1962. If this were assumed to be due only to plutonium-239 it would represent 2.5 percent of the environmental MPC.

Water Monitoring

Liquid radioactive waste materials from polonium operations at the Laboratory are processed in a special waste disposal plant designed to reduce radioactivity to a concentration level at which it may be discharged to the Great Miami River (station 2, figure 2). Liquid waste from these activities is small in volume, is handled separately as a packaged waste, and is not discharged to the river. Helium-3, which is purified at the Mound Laboratory, yields small quantities of tritium. Liquid wastes from this work, also small in volume, are treated separately (diluted with water when necessary) to assure that the radioactive content is below the maximum permissible concentration for discharge to the Great Miami River.

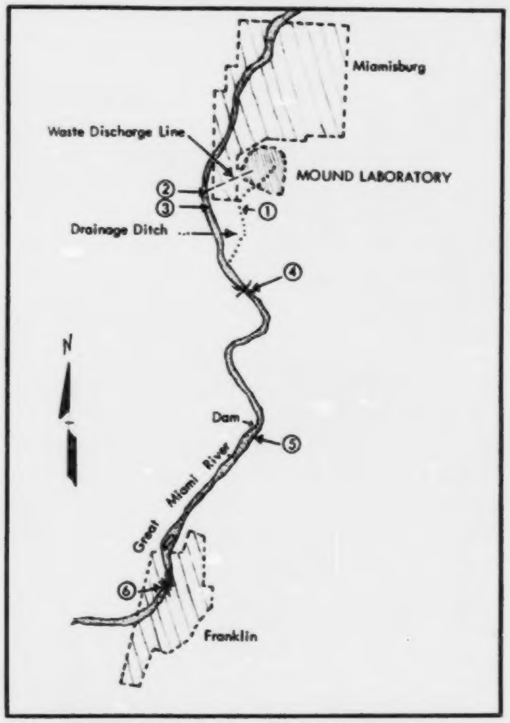

FIGURE 2.—WATER SAMPLING LOCATIONS IN GREAT MIAMI RIVER, MOUND LABORATORY

TABLE 4.—OFF-SITE WATER MONITORING FOR POLONIUM AND TRITIUM FROM MOUND LABORATORY[a]

[Average concentrations in pc/liter]

Nuclide and station number (see figure 2)	Third quarter 1962		Fourth quarter 1962		First half 1963	
	No. of samples	Concentration	No. of samples	Concentration	No. of samples	Concentration
Polonium-210						
2 (effluent)	9	0.7	8	31.3	15	45.0
3	9	2.0	8	6.5	15	1.1
4	9	1.6	8	2.9	15	0.9
5	9	1.0	8	0.0	15	0.4
6	9	1.8	8	0.7	15	0.0
Others[b]	6	0.0	6	2.1	0	—
Hydrogen-3 (tritium)						
1 (drainage ditch)	9	0	8	130,000	14	70,000
2 (effluent)	9	270,000	8	250,000	14	0
4	9	180,000	8	260,000	14	0

[a] See table 1 for applicable environmental MPC values.

[b] Single samples were collected quarterly from six locations downstream from Franklin.

Weekly water samples are collected from a drainage ditch and five locations along the Great Miami River as shown in figure 2. The drainage ditch carries away all storm sewer water and liquid tritium wastes from the plant site. Sampling location number 2 is located at the point of discharge of the laboratory effluent to the Great Miami River, and Number 6 is five miles downstream from the effluent discharge. Additional single downstream samples were collected at six locations (beyond the limits of the map in figure 2) during the third and fourth quarters of 1962.

All of the river samples are analyzed for polonium. The drainage ditch samples and some of the river samples are analyzed for tritium. Average concentrations of tritium and polonium are given in table 4. The highest polonium-210 concentration during the 12-month period was 180 pc/liter in a sample of Laboratory effluent (station 2) collected during the first half of 1963. This represents 26 percent of the MPC for polonium (see table 1). The highest value found in a tritium sample was 1,700,000 pc/liter or 34 percent of the MPC.

Recent coverage in *RHD:*

Period	Issue
January-June 1961	*January 1962*
July-December 1961	*June 1962*
January-June 1962	*March 1963*

REPORTED NUCLEAR DETONATIONS, MARCH 1964

During March 1964, the United States Atomic Energy Commission announced one nuclear detonation. This was a low yield underground detonation conducted on March 13, 1964 at the Nevada Test Site. Low yield range is defined as less than 20 kilotons. Arbitrary reference number 151 was assigned by *Radiological Health Data.*

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided this month by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 4.

1. Radiation Surveillance Network, January 1964

Division of Radiological Health, Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 73 stations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel trained in procedures necessary to obtain the measurements as described and presented below.

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and measured using a thin-window, gas-flow proportional counter, calibrated with a 38,700-pc Sr^{90}–Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula (*1*).[2] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*2*).

The January 1964 fission-product beta concentrations in surface air (extrapolated to the time of collection) are given in table 1. RSN data, along with Canadian and Mexican air data, are represented by isograms in figure 4.

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[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data, the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] $AT^{1.2} = C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T = 1$.

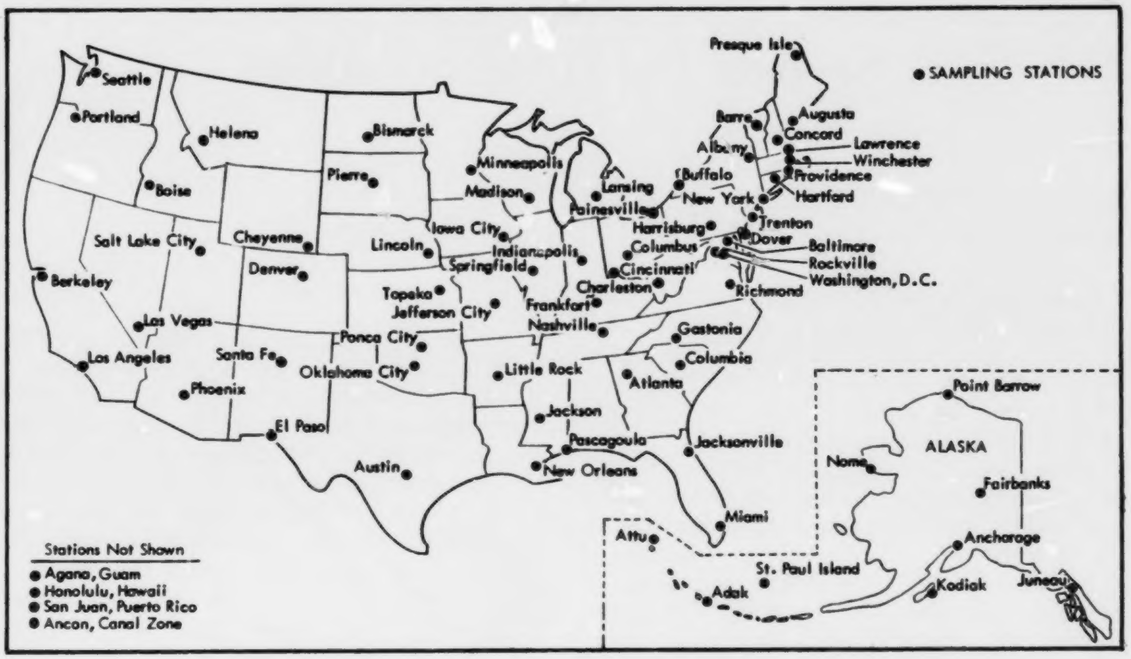
● SAMPLING STATIONS
Seattle
Portland
Helena
Boise
Salt Lake City
Berkeley
Las Vegas
Los Angeles
Phoenix
Santa Fe
Cheyenne
Denver
El Paso
Bismarck
Pierre
Lincoln
Topeka
Jefferson City
Ponca City
Oklahoma City
Austin
Minneapolis
Madison
Iowa City
Indianapolis
Springfield
Little Rock
Jackson
Pascagoula
New Orleans
Frankfort
Nashville
Lansing
Painesville
Columbus
Cincinnati
Charleston
Harrisburg
Buffalo
New York
Albany
Barre
Presque Isle
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
Trenton
Dover
Baltimore
Rockville
Washington, D.C.
Richmond
Gastonia
Columbia
Atlanta
Jacksonville
Miami
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Kodiak
Juneau
Attu
Adak
St. Paul Island
Stations Not Shown
● Agana, Guam
● Honolulu, Hawaii
● San Juan, Puerto Rico
● Ancon, Canal Zone

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, JANUARY 1964

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D=\frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totalled for the month, and the average concentration for the month, $\bar{C}$, is determined by:

$$\bar{C}=\frac{\Sigma D}{\Sigma P}\times 1000$$

The January 1964 average concentrations and total depositions are given in table 2.

TABLE 1.—GROSS BETA ACTIVITY IN SURFACE AIR, JANUARY 1964

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]
Alaska:	Adak	30	0.80	<0.10	0.40
	Anchorage	30	1.2	0.23	0.61
	Attu	29	1.2	<0.10	0.47
	Fairbanks	0	—	—	—
	Juneau	25	0.64	0.10	0.29
	Kodiak	26	0.99	<0.10	0.38
	Nome	23	1.0	0.13	0.44
	Point Barrow	30	0.80	<0.10	0.41
	St. Paul Island	22	2.5	<0.10	0.55
Ariz:	Phoenix	28	2.5	0.70	1.7
Ark:	Little Rock	28	3.1	0.62	1.5
Calif:	Berkeley	21	1.6	0.24	0.6
	Los Angeles	22	2.7	0.30	1.5
Canal Zone:	Ancon	15	0.74	0.20	0.34
Colo:	Denver	25	4.6	0.49	1.5
Conn:	Hartford	30	1.6	0.20	0.74
Del:	Dover	15	1.7	0.15	0.91
D. C:	Washington	31	1.9	0.15	0.93
Fla:	Jacksonville	28	3.7	0.18	1.5
	Miami	30	4.7	0.38	1.7
Ga:	Atlanta	23	2.3	<0.10	0.91
Guam:	Agana	31	1.4	0.14	0.62
Hawaii:	Honolulu	30	1.7	<0.10	0.70
Idaho:	Boise	29	1.3	0.15	0.59
Ill:	Springfield	28	1.3	0.38	0.78
Ind:	Indianapolis	29	2.0	0.35	1.00
Iowa:	Iowa City	27	1.7	0.41	0.88
Kans:	Topeka	29	1.8	0.55	1.0
Ky:	Frankfort	28	2.4	0.35	1.1
La:	New Orleans	30	3.1	0.29	1.1
Maine:	Augusta	30	1.8	0.31	0.91
	Presque Isle	30	1.4	<0.10	0.78
Md:	Baltimore	21	1.4	0.12	0.77
	Rockville	20	2.9	0.30	1.4
Mass:	Lawrence	30	1.9	0.31	0.92
	Winchester	30	1.5	0.17	0.72
Mich:	Lansing	30	2.6	0.38	1.1
Minn:	Minneapolis	29	1.2	0.32	0.76
Miss:	Jackson	30	3.8	0.25	1.4
	Pascagoula	2	1.4	1.3	1.3
Mo:	Jefferson City	30	1.7	0.47	0.92
Mont:	Helena	30	1.8	0.11	0.73
Nebr:	Lincoln	21	1.5	0.53	0.88
Nev:	Las Vegas	24	2.7	0.58	1.6
N. H:	Concord	21	2.0	0.25	1.2
N. J:	Trenton	30	1.9	0.22	0.86
N. Mex:	Sante Fe	26	4.0	0.76	1.5
N. Y:	Albany	21	1.3	0.16	0.75
	Buffalo	29	2.5	0.16	0.96
	New York	28	1.7	0.24	0.77
N. C:	Gastonia	29	3.9	0.22	1.2
N. Dak:	Bismarck	28	1.7	0.32	0.81
Ohio:	Cincinnati	22	2.2	0.24	1.0
	Columbus	26	2.1	0.26	1.1
	Painesville	31	3.0	0.40	1.4
Okla:	Oklahoma	26	1.9	0.42	1.1
	Ponca City	30	1.0	0.12	0.59
Ore:	Portland	21	3.0	0.28	0.86
Pa:	Harrisburg	29	1.8	0.13	0.63
P. R:	San Juan	23	2.1	<0.10	0.66
R. I:	Providence	29	1.9	0.26	0.79
S. C:	Columbia	30	3.9	<0.10	1.1
S. Dak:	Pierre	31	1.6	0.31	0.78
Tenn:	Nashville	30	2.4	0.17	1.1
Tex:	Austin	30	3.0	0.47	1.6
	El Paso	30	3.2	0.62	1.4
Utah:	Salt Lake City	31	2.6	0.40	1.1
Vt:	Barre	28	3.3	0.13	1.0
Va:	Richmond	28	1.2	0.17	0.67
Wash:	Seattle	30	0.74	0.11	0.35
W. Va:	Charleston	29	1.6	0.36	1.0
Wisc:	Madison	29	1.7	0.43	0.95
Wyo:	Cheyenne	28	3.8	0.32	1.2
Network summary		1,932	4.7	<0.10	0.94

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, JANUARY 1964

Station location		Average concentration [a] (pc/liter)	Total deposition [a] (nc/m²)
Alaska:			
	Anchorage	220	1.6
	Fairbanks	[b]—	—
	Juneau	340	51.0
Ark:	Little Rock	410	10.8
Calif:	Berkeley	220	25.3
	Los Angeles	200	9.4
Colo:	Denver	300	1.3
Conn:	Hartford	320	23.8
D. C:	Washington	330	26.0
Fla:	Jacksonville	<200	<30.8
	Miami	<200	<3.0
Ga:	Atlanta	—	—
Hawaii:	Honolulu	230	21.5
Idaho:	Boise	—	—
Ill:	Springfield	—	—
Ind:	Indianapolis	390	12.3
Iowa:	Iowa City	1,000	6.1
Kans:	Topeka	—	—
Ky:	Frankfort	360	12.6
La:	New Orleans	240	6.7
Maine:	Augusta	250	29.8
	Presque Isle	—	—
Md:	Baltimore	500	26.6
Mass:	Lawrence	400	50.9
	Winchester	510	38.9
Mich:	Lansing	670	18.2
Minn:	Minneapolis	670	5.6
Miss:	Jackson	200	34.7
Mo:	Jefferson City	350	5.5
Mont:	Helena	460	3.0
Nebr:	Lincoln	—	—
Nev:	Las Vegas	—	—
N. J:	Trenton	500	11.2
N. Mex:	Santa Fe	620	3.9
N. Y:	Albany	230	15.2
N. C:	Gastonia	220	26.8
N. Dak:	Bismarck	280	3.7
Ohio:			
	Columbus	370	15.7
	Painesville	3,700	152.4
Okla:	Oklahoma City	—	—
	Ponca City	430	7.7
Ore:	Portland	230	24.2
Pa:	Harrisburg	260	10.8
P. R:	San Juan	200	6.4
R. I:	Providence	350	30.2
S. C:	Columbia	200	53.1
S. Dak:	Pierre	—	—
Tenn:	Nashville	500	36.3
Tex:	Austin	—	—
	El Paso	1,200	3.6
Utah:	Salt Lake City	460	11.1
Vt:	Barre	340	27.2
Va:	Richmond	300	26.2
Wash:	Seattle	280	33.2
W. Va:	Charleston	250	15.6
Wisc:	Madison	520	9.9
Wyo:	Cheyenne	—	—

[a] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by $D = \frac{C \times P}{1000} = <0.2P$ in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] Dash indicates no evaporated sample received.

2. Canadian Air Monitoring Program,[3] January 1964

Department of National Health and Welfare

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for January 1964 are given in table 3 and presented in conjunction with U. S. and Mexican data by an isogram map (figure 4).

TABLE 3.—GROSS BETA ACTIVITY IN AIR, CANADA, JANUARY 1964

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	30	2.8	0.3	0.8
Coral Harbour	31	2.1	0.3	1.1
Edmonton	31	1.6	0.2	0.7
Ft. Churchill	31	2.5	0.4	1.0
Ft. William	31	1.9	0.3	1.0
Fredericton	31	1.9	0.0	1.0
Goose Bay	31	1.7	0.5	1.1
Halifax	24	3.6	0.3	1.3
Inuvik	30	1.6	0.6	1.0
Montreal	31	2.2	0.2	1.0
Moosonee	31	1.8	0.6	1.3
Ottawa	28	1.9	0.3	0.9
Quebec	31	2.0	0.3	1.0
Regina	31	2.5	0.4	0.8
Resolute	31	1.9	0.1	0.8
St. John's, Nfld	29	2.6	0.1	1.0
Saskatoon	30	3.0	0.2	0.9
Sault Ste. Marie	31	1.5	0.1	0.8
Toronto	31	0.6	0.1	0.3
Vancouver	31	1.8	0.1	0.5
Whitehorse	31	1.1	0.1	0.5
Windsor	29	2.1	0.4	1.1
Winnipeg	31	1.5	0.3	0.9
Yellowknife	31	1.5	0.4	0.8
Network summary	727	3.6	0.0	0.9

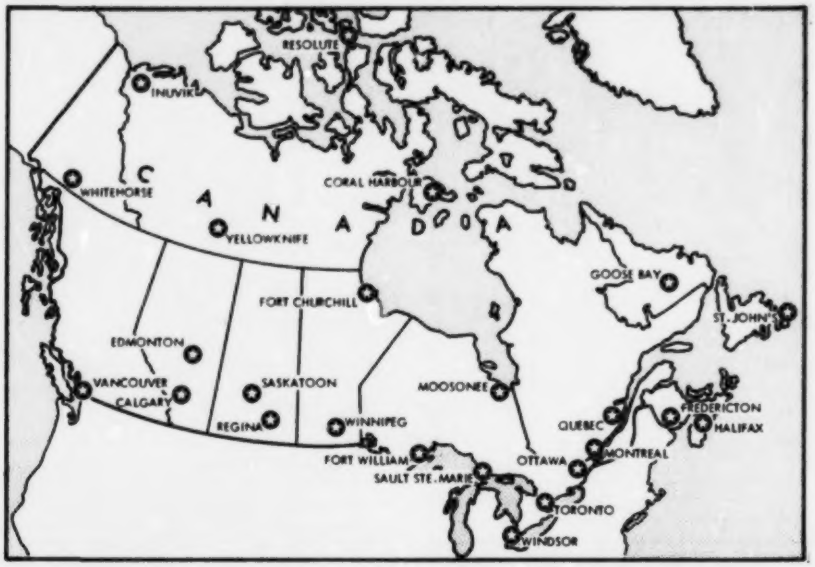

FIGURE 2.—CANADIAN AIR AND PRECIPITATION STATIONS, JANUARY 1964

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[3] Data from *Radiation Protection Programs*, *2*:11-24, Radiation Protection Division, Canadian Department of National Health and Welfare (February 1964).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450° C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}-Y^{90} source. Gross beta activities for January 1964 are given in table 4. Radionuclide analyses appear on page 206.

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, JANUARY 1964

Station	Total beta activity	
	pc/liter	nc/m²
Calgary	491	2.9
Coral Harbour	1307	8.3
Edmonton	288	5.2
Ft. Churchill	243	2.9
Ft. William	903	26.8
Fredericton	470	26.1
Goose Bay	325	12.7
Halifax	303	42.2
Inuvik	195	4.2
Montreal	368	40.7
Moosonee	287	18.2
Ottawa	227	14.8
Quebec	270	41.2
Regina	288	3.2
Resolute	898	22.8
St. John's, Nfld	339	43.5
Saskatoon	416	6.4
Sault Ste. Marie	267	29.2
Toronto	394	23.2
Vancouver	354	75.1
Whitehorse	219	3.7
Windsor	402	27.4
Winnipeg	340	5.7
Yellowknife	317	3.6
Average	413	20.4

3. Mexican Air Monitoring Program, January 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comision Nacional de Energia Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network consists of 17 stations (see figure 3), 12 of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico City while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Merida, the Instituto de Zonas Deserticas of the University of San Luis Potosi, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6 x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactiva", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of naturally occurring radon and thoron daughters. Data are not extrapolated to time of collection.

The maximum, minimum and average fission product beta concentrations in surface air during January 1964 are presented in table 5. The data are also represented in the beta activity isogram map of North America, figure 4.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, JANUARY 1964

[Concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Acapulco [a]	2	0.2	0.1	—
Ciudad Juárez	21	3.3	0.5	1.2
Chihuahua	23	3.7	0.8	1.8
Ensenada	8	2.7	0.3	1.5
Guadalajara	15	0.8	0.1	0.2
Guaymas [a]	0	—	—	—
La Paz	21	3.0	0.4	1.8
Matamoros [a]	2	0.6	0.5	—
Mazatlán [a]	0	—	—	—
Mérida	11	1.8	0.2	0.7
Mexico City	22	0.9	0.1	0.2
Nuevo Laredo	4	1.8	0.8	1.2
San Luis Potosí	4	0.4	0.1	0.3
Tampico	9	1.4	0.4	0.6
Torreón	12	3.6	0.6	1.5
Tuxtla Gutiérrez [a]	0	—	—	—
Veracruz [a]	—	—	—	—

[a] Equipment out of order.

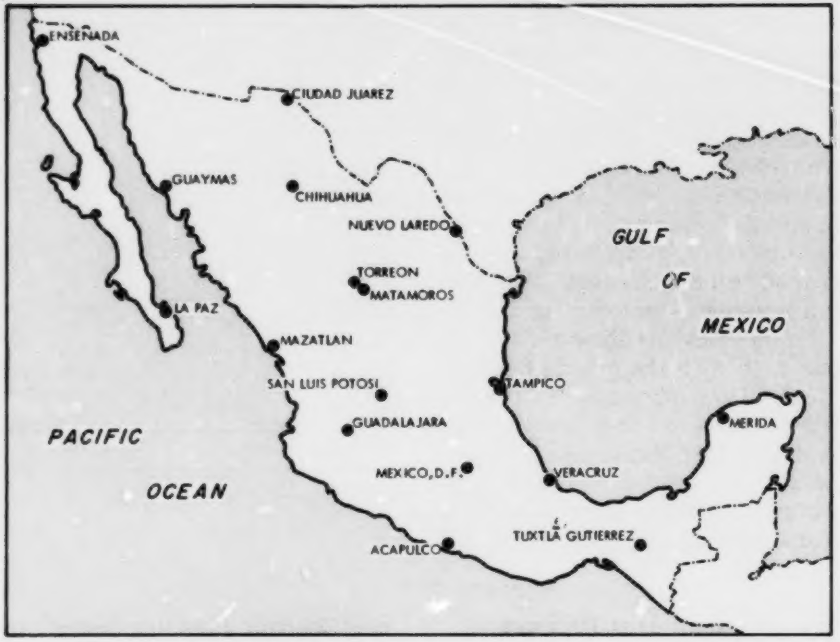

FIGURE 3.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

4. Pan American Air Sampling Program January 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Caracas, Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The January 1964 air monitoring results from the three participating countries are given in table 6. The Caracas station is shown on the gross beta concentration isogram map (figure 4). The January average at this station, adjusted by the RSN intercalibration factor[4] is 0.35 pc/m^3, which is below the lowest isogram used on the map (0.5 pc/m^3).

TABLE 6.—GROSS BETA ACTIVITY IN AIR, JANUARY 1964

[Concentrations in pc/m^3]

Sampling stations	No. of samples	Maximum	Minimum	Average[a]
Caracas, Venezuela	20	0.49	<0.10	0.27
Lima, Peru	0	—	—	—
Santiago, Chile	16	0.26	<0.10	<0.12

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

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[4] The RSN factor is 1.28 (see page 1-14).

5. Gross Beta Activity in Air, North America, January 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[illegible] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the new 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are, therefore, not the same as were previously used.

Figure 4 shows the January 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

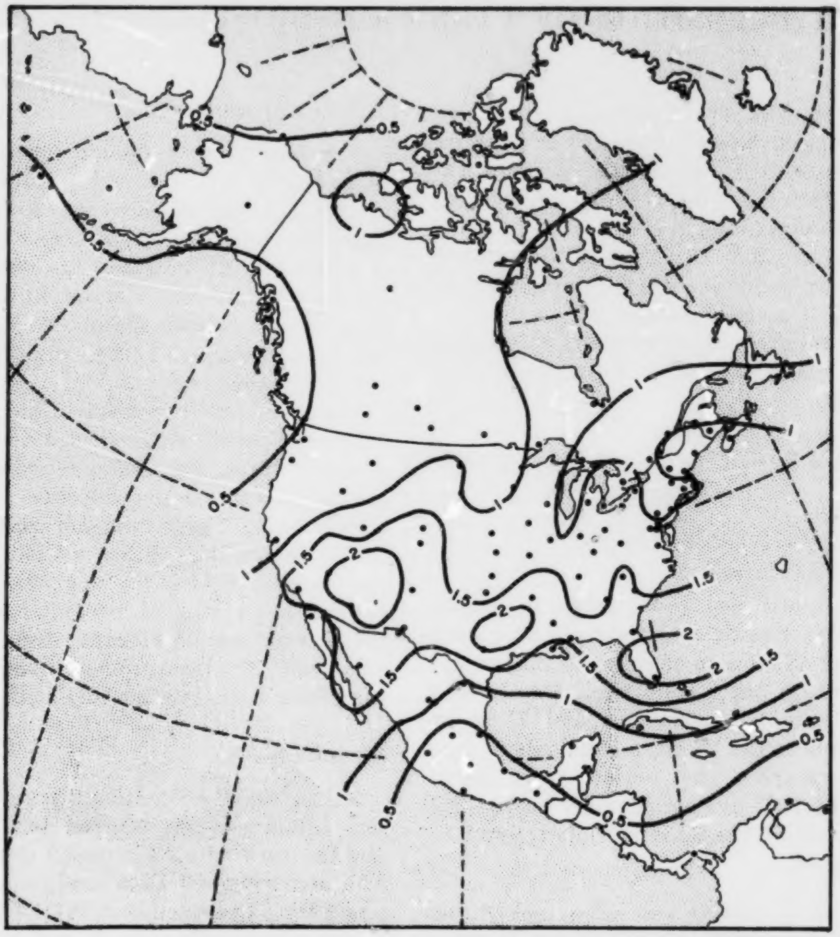

FIGURE 4.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR THROUGHOUT NORTH AMERICA, JANUARY 1964

[illegible] The January through December 1963 isogram maps were published in the May 1963 through April 1964 issues of *Radiological Health Data*.

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(*3*) Bird, R. M., A. H. Booth, and P. G. Mar: *Annual Report for 1959 on the Radioactive Fallout Study Program, CNHW-RP-3*, Department of National Health and Welfare, Ottawa, Canada (May 1960).

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(*8*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of Some Systems Employed in Monitoring Fission Products in the Atmosphere, NRL Report 5850*, Naval Research Laboratory, Washington, D. C. 20390 (November 13, 1962); abstracted in *Radiological Health Data*, December 1962.

(*9*) Lockhart, L. B., Jr., and R. L. Patterson, Jr.: *Intercalibration of the Major North American Networks Employed in Monitoring Airborne Fission Products, NRL Report 6025*, Naval Research Laboratory, Washington, D. C. 20390 (December 1963); summarized in *Radiological Health Data*, January 1964.

MONTHLY DEPOSITION OF VARIOUS RADIONUCLIDES

For the purpose of this section the word "fallout" refers to the deposition of radioactive materials on the earth's surface, normally expressed in terms of the activity of selected radionuclides deposited on a unit area during a given period of time. Unless otherwise stated, fallout measurements include both precipitation and dry fallout (settled dust).

Reports of fallout measurements at selected stations in North and South America are presented below.

Fallout in the United States and Other Areas,[1] April—June 1963

Health and Safety Laboratory Atomic Energy Commission

Monthly fallout deposition rates are determined by the Health and Safety Laboratory (HASL) for 48 sites in the United States and 104 locations in other countries. HASL data from 10 of the U. S. stations and 21 other selected points in the Western Hemisphere (see figure 1) covering the period from April through June 1963 are summarized below. All of the stations of the 80th Meridian Network are represented.

Methods of Collection

Two methods of fallout collection are employed by HASL. In the first, precipitation and dry fallout are collected for a period of one month in stainless steel pots with exposed areas of 0.076 m^2. At the end of the collection period, the contents are transferred, by careful scrubbing with a rubber spatula, to a polyethylene sample bottle which is then shipped to the laboratory for analysis.

The second method involves the use of a polyethylene funnel, with exposed area of 0.072m^2 attached to an ion exchange column. After a one-month collection, the inside of the funnel is wiped with a tissue, and the tissue is inserted in the end of the column, which is then sealed and sent to HASL for analysis. It has been shown that at the 95 percent confidence level there was no significant difference in the strontium-90 measurements obtained from samples collected by the two methods (*1*).

Strontium-90

All of the HASL fallout samples—both pot and column—were assayed for strontium-90 and the ratio of strontium-89 to strontium-90. The strontium-90 data are given in tables 1 and 2 for 58 selected stations. Where duplicate samples were collected, the average values are given.

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[1] The data in this article were taken from *Fallout Program Quarterly Summary Report, HASL-144*: 2-172, Health and Safety Laboratory, AEC, New York, N.Y. 10014.

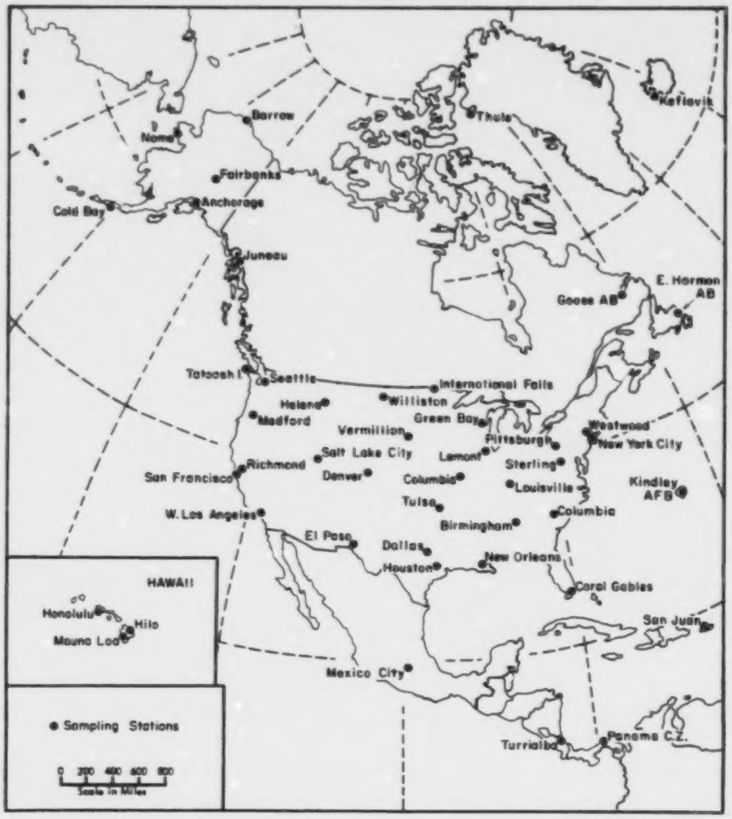
Barrow
Nome
Fairbanks
Cold Bay
Anchorage
Juneau
Thule
Keflavik
Goose AB
E. Harmon AB
Tatoosh I.
Seattle
International Falls
Helena
Williston
Medford
Green Bay
Vermillion
Westwood
Pittsburgh
New York City
Salt Lake City
Lemont
Sterling
Richmond
San Francisco
Denver
Columbia
Louisville
Kindley AFB
Tulsa
W. Los Angeles
Columbia
Birmingham
El Paso
Dallas
New Orleans
Houston
Coral Gables
HAWAII
Honolulu
Hilo
Mauna Loa
San Juan
Mexico City
Sampling Stations
0 200 400 600 800
Scale in Miles
Panama C.Z.
Turrialba

FIGURE 1.—HASL FALLOUT SAMPLING LOCATIONS

Other Radionuclides

Laboratories at Richmond, California; Westwood, New Jersey; Pittsburgh, Pennsylvania; and Houston, Texas have analyzed duplicate monthly pot samples for various radionuclides. The monthly deposition rates for Zr^{95} and Cs^{137}, as well as the Sr^{89}/Sr^{90} ratio and precipitation depth, are presented in table 3. The strontium-90 values for these stations are included in table 1.

TABLE 1.—MONTHLY STRONTIUM-90 FALLOUT IN THE UNITED STATES, HASL, APRIL-JUNE 1963

[Deposition in nc/m²]

Sampling location and type of collection		April	May	June
Ala:	Birmingham (pot)	5.19	2.70	3.04
Alaska:	Anchorage (col)	0.78	0.65	1.38
	Barrow (col)	[a]—	—	—
	Cold Bay (col)	1.20	1.04	1.06
	Fairbanks (col)	0.40	0.30	2.43
	Juneau (col)	0.70	1.13	2.80
	Nome (col)	—	—	—
Calif:	Los Angeles (pot)	1.58	0.23	0.59
	Palo Alto (col)	1.52	0.69	0.16
	Palo Alto (pot)	1.85	0.83	0.11
	Richmond (pot)	2.61	0.41	0.1
	San Francisco (col)	1.50	0.34	1.18
Colo:	Denver (col)	0.15	1.64	4.05
Fla:	Coral Gables (pot)	3.63	2.35	2.38
Hawaii:	Hilo (col)	0.33	6.17	4.83
	Mauna Loa (col)	0.31	1.42	0.76
	Oahu (pot)	2.97	1.19	3.75
Ill:	Lemont (pot)	1.39	1.76	3.83
Ky:	Louisville (pot)	1.53	5.80	4.02
La:	New Orleans (col)	0.88	1.05	1.18
Minn:	International Falls (col)	5.10	5.05	1.88
Mo:	Columbia (col)	1.97	1.14	1.93
Mont:	Helena (col)	1.22	1.52	4.36
N. J:	Westwood (col)	2.87	3.71	1.82
	Westwood (pot)	3.01	3.80	2.43
N. Y:	New York (pot)	1.43	1.75	1.82
N. Dak:	Williston (col)	0.89	0.87	3.94
Okla:	Tulsa (pot)	1.81	2.56	0.69
Ore:	Medford (col)	1.61	1.90	1.01
Pa:	Pittsburgh (col)	2.72	2.18	—
	Pittsburgh (pot)	3.05	2.20	—
S. C:	Columbia (col)	2.98	1.18	2.50
S. Dak:	Vermillion (pot)	2.92	2.96	5.05
Tex:	Dallas (col)	2.25	1.37	0.20
	El Paso (col)	0.10	0.51	0.21
	Houston (col)	0.01	0.26	2.17
	Houston (pot)	0.83	0.97	2.75
Va:	Sterling (col)	2.38	0.85	1.59
Utah:	Salt Lake City (pot)	7.82	0.80	4.78
Wash:	Seattle (pot)	2.06	0.52	2.11
	Tatoosh I. (col)	2.75	1.26	1.13
Wis:	Green Bay (col)	1.32	1.68	2.64

[a] Dash indicates no sample received.

TABLE 2.—MONTHLY STRONTIUM-90 FALLOUT IN NORTH AND SOUTH AMERICA, HASL, APRIL–JUNE 1963

[Deposition in nc/m²]

Station	Collection period, 1963		
	April	May	June
Greenland, Thule	0.02	0.07	0.20
Iceland, Keflavik	1.71	0.93	1.77
Canada, Goose AB	0.49	1.51	6.29
Moosonee [a]	1.46	3.10	3.55
Bermuda	0.33	0.09	0.27
Puerto Rico, San Juan	0.93	0.84	0.84
Mexico, Mexico City	0.91	0.16	1.56
Costa Rica, Turrialba	0.93	0.48	0.02
Canal Zone	0.86	1.59	0.58
Venezuela, Caracas	0.22	0.77	0.08
Colombia, Bogota	0.14	0.05	0.02
Equador, Quito	0.03	0.02	not received
Guayaquil [a]	0.04	0.01	0.03
Brazil, Recife	0.03	0.05	0.07
Peru, Lima [a]	0.01	0.01	0.01
Bolivia, La Paz	0.01	0.02	0.03
Chacaltaya [a]	[b]—	0.03	0.12
Chile, Antofagasta [a]	0.01	0.01	0.02
Santiago [a]	0.01	0.05	0.10
Puerto Montt [a]	0.37	0.30	0.37
Punta Arenas [a]	0.09	0.08	0.08

[a] 80th Meridian Network station. [b] Sample not received.

TABLE 3.—RADIOCHEMICAL ANALYSES OF POT FALLOUT SAMPLES, HASL, APRIL–JUNE 1963

[Deposition in nc/m²]

Location and analyses	Collection period, 1963		
	April	May	June
California, Richmond			
Precipitation (mm)	100	15	dry
Sr^{89}/Sr^{90} ratio	9.0	6.2	2.2
Zr^{95} (nc/m²)	54.6	10.9	2.0
Cs^{137} (nc/m²)	4.4	0.64	0.17
New Jersey, Westwood			
Precipitation (mm)	24	64	90
Sr^{89}/Sr^{90} ratio	7.6	5.3	3.6
Zr^{95} (nc/m²)	40.2	51.8	23.9
Cs^{137} (nc/m²)	4.4	5.9	3.7
Pennsylvania, Pittsburgh			
Precipitation (mm)	77	42	
Sr^{89}/Sr^{90} ratio	9	7	
Zr^{95} (nc/m²)	38.6	21.2	
Cs^{137} (nc/m²)	5.7	4.0	
Texas, Houston			
Precipitation (mm)	23	16	—
Sr^{89}/Sr^{90} ratio	5.8	6.6	0.2
Zr^{95} (nc/m²)	20.1	16.0	17.5
Cs^{137} (nc/m²)	8.2	20.1	5.4

Fallout Measurements in Canada, October—December 1963

Department of National Health and Welfare
Ottawa, Canada

The monthly accumulated precipitation samples collected in conjunction with the Canadian air sampling network described earlier in this issue represent total fallout (wet and dry), since they are collected in deep pots lined with polyethylene. The radiochemical analyses of these samples for October through December 1963 are given in table 4.

TABLE 4.—ANALYSIS FOR SPECIFIC RADIONUCLIDES IN CANADIAN FALLOUT, OCTOBER–DECEMBER 1963

[Deposition in nc/m²]

Station	October					November					December				
	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}	Sr^{89}	Sr^{90}	Cs^{137}	Zr^{95}	Ba^{140}
Calgary	0.10	0.10	0.21	0.47	0.01	0.06	0.14	0.45	0.63	0.01	0.00	0.09	0.46	0.47	0.07
Coral Harbour	0.13	0.52	0.99	[a]—	—	0.07	0.14	0.29	—	—	0.07	0.25	0.52	—	—
Edmonton	0.55	0.51	0.44	—	—	0.00	0.14	0.28	—	—	0.06	0.17	—	—	—
Ft. Churchill	0.26	0.22	0.37	—	—	0.06	0.09	0.14	—	—	0.00	0.18	0.26	—	—
Ft. William	0.35	0.49	0.86	—	—	0.19	0.36	1.28	—	—	0.05	0.23	0.33	—	—
Fredericton	0.63	0.81	1.69	—	—	0.64	1.07	1.80	—	—	0.00	0.16	—	—	—
Goose Bay	0.69	0.62	1.46	—	—	0.35	0.57	0.99	—	—	0.06	0.26	0.41	—	—
Halifax	0.61	0.86	1.43	2.42	0.02	0.91	1.35	2.64	2.93	0.04	0.39	0.76	1.47	0.59	0.01
Inuvik	0.48	0.41	0.77	—	—	0.09	0.09	0.29	—	—	0.00	0.15	0.29	—	—
Montreal	0.29	0.30	0.85	1.40	0.03	—	—	—	—	—	0.08	0.19	0.35	0.35	0.02
Moosonee	0.55	0.72	0.99	—	—	0.31	0.58	1.09	—	—	0.00	0.25	0.44	—	—
Ottawa	0.50	0.45	0.93	—	—	0.55	0.99	1.00	—	—	0.08	0.20	0.44	—	—
Quebec	1.51	1.51	2.84	—	—	0.56	0.93	2.24	—	—	0.21	0.72	1.88	—	—
Regina	0.10	0.79	0.61	—	—	0.07	0.13	0.33	—	—	0.04	0.06	0.19	—	—
Resolute	0.57	0.55	0.76	—	—	0.18	1.09	0.82	—	—	0.29	0.53	1.12	—	—
St. John's, Nfld	0.81	0.86	2.38	—	—	—	—	—	—	—	0.46	1.17	1.94	—	—
Saskatoon	0.22	0.29	0.76	—	—	0.08	0.20	0.40	—	—	0.00	0.16	0.17	—	—
Sault Ste. Marie	[b]	[b]	[b]	[b]	[b]	0.44	1.04	1.40	—	—	0.15	0.44	0.50	—	—
Toronto	0.16	0.20	0.18	—	—	0.28	0.53	0.93	—	—	0.08	0.29	0.65	—	—
Vancouver	1.68	2.02	3.88	5.95	0.06	0.25	0.58	1.22	1.75	0.20	1.10	2.10	3.86	2.11	0.06
Whitehorse	0.10	0.10	0.22	—	—	—	—	—	—	—	0.00	0.00	0.22	—	—
Windsor	0.32	0.51	0.84	—	—	0.37	0.54	0.37	—	—	0.21	0.20	0.60	—	—
Winnipeg	0.45	0.58	1.99	2.08	0.02	0.13	0.23	0.50	0.22	0.01	0.07	0.13	0.49	0.22	0.02
Yellowknife	0.62	0.75	0.79	—	—	0.19	0.21	1.00	—	—	0.04	0.05	0.11	—	—

[a] Dash indicates no analysis. [b] No sample received.

TABLE 5.—STRONTIUM-90 DEPOSITION IN CANADA, 1963 SUMMARY

[Monthly deposition in nc/m²]

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
Calgary	0.25	0.13	0.23	1.10	0.97	6.77	5.41	1.87	0.40	0.10	0.14	0.09
Halifax (Shearwater)	0.51	[a]—	—	1.98	4.34	1.26	1.86	2.36	1.20	0.86	1.35	0.76
Montreal	0.25	0.87	1.42	2.98	2.68	3.20	—	4.38	1.97	0.30	—	0.19
Vancouver	0.47	1.80	1.38	2.54	0.36	0.89	2.04	0.92	0.82	2.02	0.58	2.10
Winnipeg	0.19	0.51	0.22	2.84	4.15	—	—	2.56	0.64	0.58	0.23	0.13

[a] Dash indicates no analyses.

A 1963 summary of the strontium-90 deposition for five stations is given in table 5. Radiochemical analyses of fallout samples for these five stations for the months of October 1962 through April 1963 were included with the tables of gross beta in precipitation in the February through August 1963 issues of *RHD*. May and June radiochemical data for 23 stations were reported in the October 1963 *RHD*, and July through August data for the full 24 station networks were given in the January 1964 *RHD*.

REFERENCE

(*1*) Ong, L. D. Y., Homogeneity Between Pot and Ion Exchange Column Strontium-90 Measurements, *Fallout Program Quarterly Summary Report, HASL-135:* 256-69, Office of Technical Services, Department of Commerce, Washington 25, D. C. (April 1, 1963), price $4.00.

Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, January 1964

Division of Radiological Health and
Division of Environmental Engineering
and Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk monitoring network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composite sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January

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1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

Analytical Errors

Iodine-131, cesium-137, and barium-140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium-89 and strontium-90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples, this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. The $\pm 2\sigma$ range about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below, the counting error constitutes nearly all of the analytical error.

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium-40 concentrations determined from the gamma spectrum.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations.

Data Presentation

Table 2 presents summaries of the analyses for January 1964 (December 29, 1963—January 25, 1964). Although not shown in table 2, the iodine-131 and barium-140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero is used as the best approximation to a nondetectable concentration of iodine-131 or barium-140. A similar procedure is used for the network average. Table 3 shows the distribution of the network's stations according to monthly average radionuclide concentrations in milk.

Figures 1, 2, and 3 are isogram maps showing the estimated strontium-89, strontium-90, and cesium-137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium-90 concentrations in pasteurized milk from 16 selected cities in the sampling program are presented in figure 4. Each graph shows the strontium-90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium-140 analysis.

TABLE 2.—RADIOACTIVITY IN PASTEURIZED MILK, JANUARY 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	
Ala:	Montgomery	1.22	1.24	1.5	1.5	5	<5	21	22	85	95	February
Alaska:	Palmer	1.20	1.19	1.6	1.6	15	10	31	27	180	170	March
Ariz:	Phoenix	1.16	1.20	1.7	1.6	<5	<5	3	4	30	20	May
Ark:	Little Rock	1.20	1.19	1.5	1.4	10	<5	40	39	130	150	March
Calif:	Sacramento	1.22	1.27	1.6	1.6	<5	<5	8	11	60	60	April
	San Francisco	1.22	1.23	1.6	1.6	5	5	9	11	70	80	February
Canal Zone:	Cristobal	1.13	1.15	1.5	1.5	<5	<5	5	6	40	50	March
Colo:	Denver	1.19	1.25	1.6	1.7	15	<5	17	18	85	80	April
Conn:	Hartford	1.19	1.16	1.6	1.7	10	<5	25	24	170	180	April
Del:	Wilmington	1.21	1.21	1.7	1.5	5	<5	23	22	130	145	May
D. C:	Washington	1.17	1.20	1.5	1.6	10	<5	17	18	80	105	February
Fla:	Tampa	1.22	1.27	1.4	1.4	5	<5	16	14	250	185	May
Ga:	Atlanta	1.19	1.21	1.5	1.6	10	<5	29	30	120	145	February
Hawaii:	Honolulu	1.15	1.19	1.7	1.6	10	<5	11	9	85	80	March
Idaho:	Idaho Falls	1.19	1.19	1.6	1.7	15	10	26	31	170	200	May
Ill:	Chicago	1.18	1.17	1.7	1.6	10	<5	20	21	110	145	February
Ind:	Indianapolis	1.25	1.22	1.6	1.6	10	<5	22	22	100	120	April
Iowa:	Des Moines	1.18	1.22	1.5	1.5	15	5	25	27	100	110	May
Kans:	Wichita	1.16	1.19	1.6	1.6	10	10	18	22	65	75	March
Ky:	Louisville	1.16	1.20	1.5	1.6	15	5	30	31	100	125	May
La:	New Orleans	1.24	1.28	1.5	1.5	15	<5	44	48	135	155	March
Maine:	Portland	1.22	1.21	1.6	1.6	10	5	35	32	235	230	May
Md:	Baltimore	1.14	1.20	1.4	1.5	10	<5	20	19	105	110	May
Mass:	Boston	1.22	1.19	1.6	1.7	15	<5	36	35	250	265	February
Mich:	Detroit	1.20	1.17	1.6	1.6	5	<5	20	20	120	140	April
	Grand Rapids	1.23	1.22	1.6	1.5	5	<5	22	23	130	145	May
Minn.	Minneapolis	1.18	1.17	1.6	1.6	25	10	33	38	155	180	February
Miss:	Jackson	1.25	1.27	1.4	1.4	15	5	36	37	105	120	April
Mo:	Kansas City	1.17	1.20	1.5	1.5	15	<5	29	29	85	105	April
	St. Louis	1.20	1.23	1.6	1.5	15	10	21	22	85	105	March
Mont:	Helena	1.20	1.23	1.6	1.5	10	10	29	28	195	235	March
Nebr:	Omaha	1.20	1.19	1.6	1.5	25	10	25	23	95	100	May
Nev:	Las Vegas	1.14	1.30	1.7	1.7	<5	<5	10	19	80	95	February
N. H:	Manchester	1.24	1.23	1.6	1.7	10	<5	37	35	275	265	May
N. J:	Trenton	1.20	1.17	1.6	1.6	10	10	19	20	120	140	April
N. Mex:	Albuquerque	1.16	1.18	1.6	1.6	<5	<5	11	11	50	60	March
N. Y:	Buffalo	1.18	1.16	1.7	1.6	10	<5	23	21	145	165	April
	New York	1.20	1.15	1.7	1.6	15	<5	30	28	175	190	February
	Syracuse	1.19	1.18	1.7	1.6	10	<5	22	23	150	165	March
N. C:	Charlotte	1.19	1.24	1.5	1.4	15	<5	30	30	105	110	March
N. Dak:	Minot	1.18	1.18	1.6	1.6	40	10	55	68	145	165	May
Ohio:	Cincinnati	1.23	1.21	1.6	1.6	10	<5	23	24	90	130	April
	Cleveland	1.22	1.22	1.7	1.6	5	<5	22	22	105	130	March
Okla:	Oklahoma City	1.17	1.20	1.5	1.6	5	<5	21	22	70	85	February
Ore:	Portland	1.21	1.23	1.6	1.6	20	10	30	29	180	170	April
Pa:	Philadelphia	1.22	1.21	1.6	1.6	5	<5	21	20	120	140	March
	Pittsburgh	1.27	1.20	1.6	1.6	10	<5	29	30	145	160	March
P. R:	San Juan	1.16	1.18	1.5	1.6	5	<5	12	11	65	55	March
R. I:	Providence	1.21	1.18	1.6	1.6	5	<5	27	26	175	180	May
S. C:	Charleston	1.21	1.21	1.5	1.5	10	<5	27	33	120	120	April
S. Dak:	Rapid City	1.20	1.21	1.7	1.6	25	10	42	40	170	180	February
Tenn:	Chattanooga	1.23	1.26	1.5	1.6	15	10	35	35	120	140	February
	Memphis	1.22	1.25	1.5	1.5	10	<5	28	28	75	90	May
Tex:	Austin	1.18	1.20	1.5	1.6	<5	<5	8	8	40	40	February
	Dallas	1.20	1.23	1.5	1.6	5	<5	19	21	75	80	April
Utah:	Salt Lake City	1.19	1.25	1.6	1.6	15	5	26	28	170	200	March
Vt:	Burlington	1.21	1.18	1.6	1.7	10	<5	28	28	200	220	April
Va:	Norfolk	1.17	1.20	1.5	1.6	10	<5	21	20	90	100	April
Wash:	Seattle	1.21	1.20	1.6	1.6	15	<5	24	20	155	120	February
	Spokane	1.21	1.24	1.7	1.6	20	10	31	40	160	155	April
W. Va:	Charleston	1.17	1.19	1.4	1.6	15	<5	26	25	85	105	February
Wis:	Milwaukee	1.28	1.23	1.8	1.7	<5	<5	19	21	135	160	May
Wyo:	Laramie	1.18	1.21	1.6	1.5	15	10	20	19	115	105	May
Network average		1.20	1.21	1.6	1.6	11	<5	24.2	24.9	123	134	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

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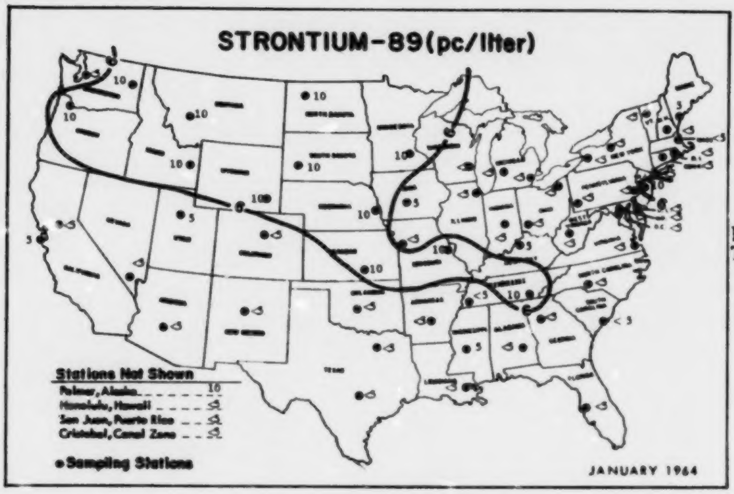
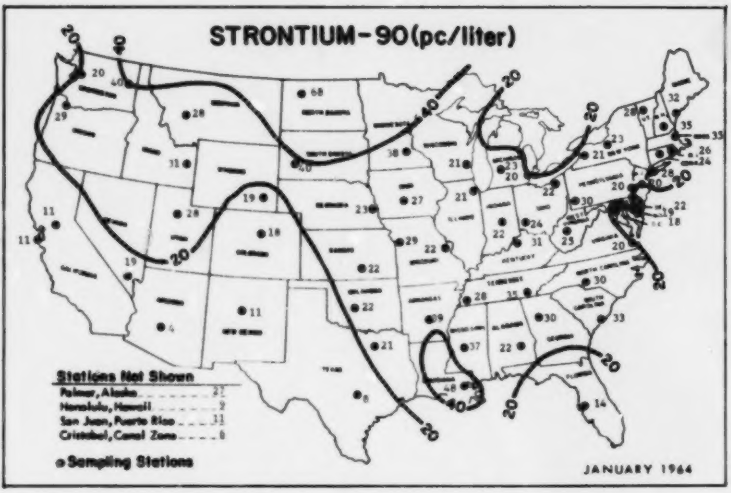

STRONTIUM-89(pc/liter)
Stations Not Shown
Palmer, Alaska 10
Honolulu, Hawaii <5
San Juan, Puerto Rico <5
Cristobal, Canal Zone <5
● Sampling Stations
JANUARY 1964

FIGURE 1.—STRONTIUM-89 CONCENTRATIONS IN PASTEURIZED MILK, JANUARY 1964

FIGURE 2.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, JANUARY 1964


STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 21
Honolulu, Hawaii 9
San Juan, Puerto Rico 11
Cristobal, Canal Zone 6
● Sampling Stations
JANUARY 1964

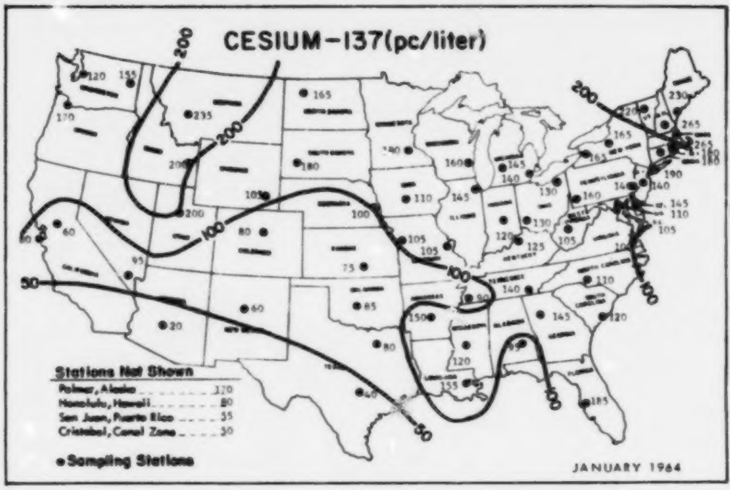

CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 120
Honolulu, Hawaii 80
San Juan, Puerto Rico 55
Cristobal, Canal Zone 50
● Sampling Stations
JANUARY 1964

FIGURE 3.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, JANUARY 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, JANUARY 1964 [a]

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5	43	<1-4	1	<10	63	<5-45	2	<10	63
5	6	5-9	3			50-95	13		
10	14	10-14	5			100-145	25		
		15-19	5			150-195	16		
		20-24	21			200-245	5		
		25-29	11			250-295	2		
		30-34	7						
		35-39	6						
		40-44	2						
		≥45	2						
Total	63	Total	63	Total	63	Total	63	Total	63

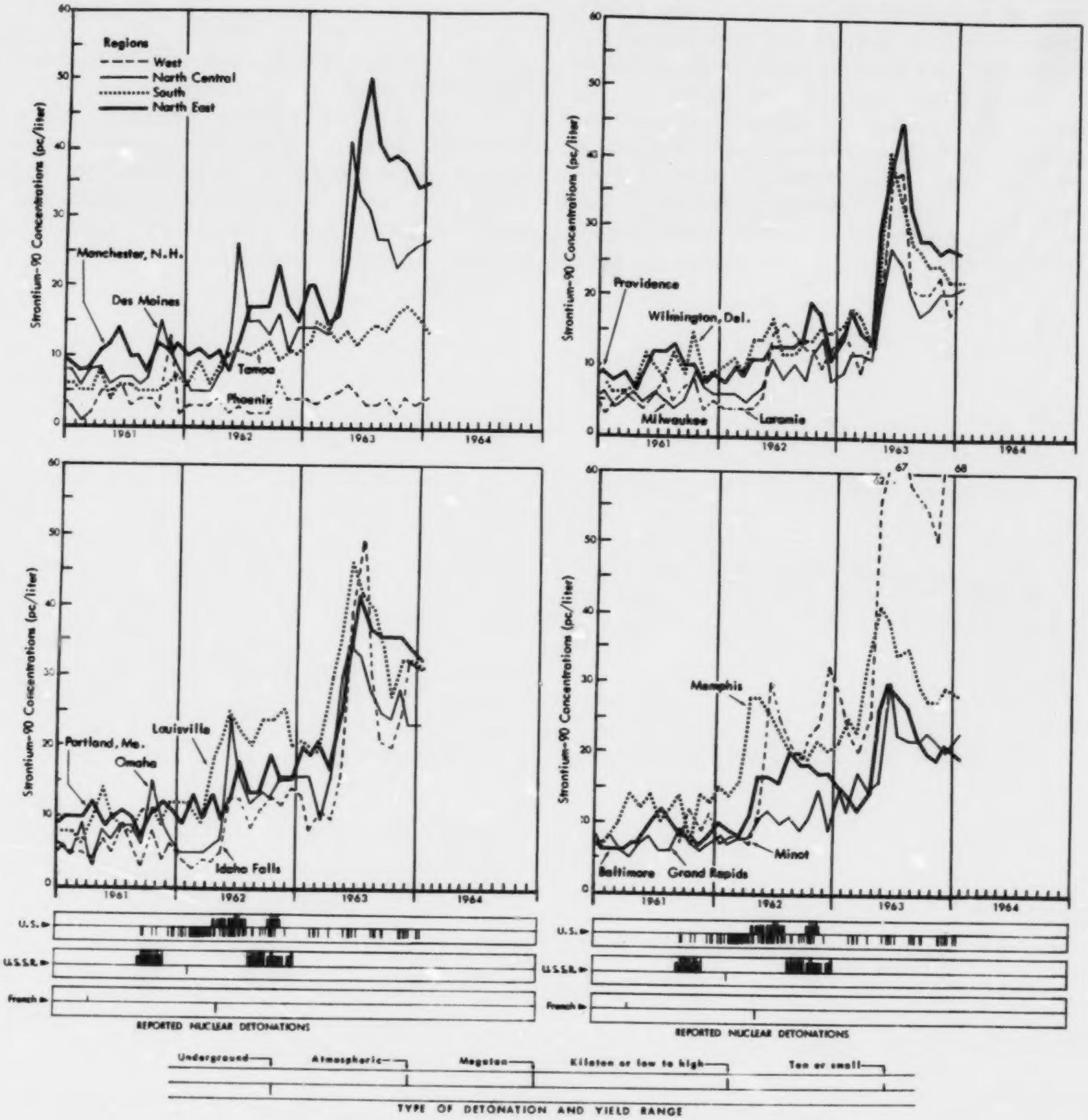


FIGURE 4.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, FOR SELECTED CITIES, JANUARY 1964

2. Indiana Milk Network, January 1964

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 5).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium-89 and strontium–90 analyses are performed monthly for each station.

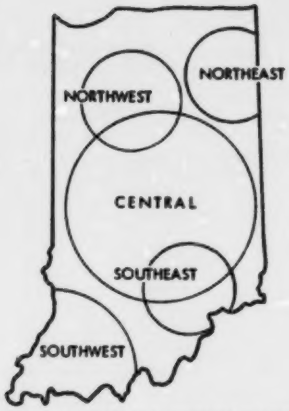


FIGURE 5.—INDIANA MILK SAMPLING LOCATIONS

An ion exchange analytical procedure (*2*) is used for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

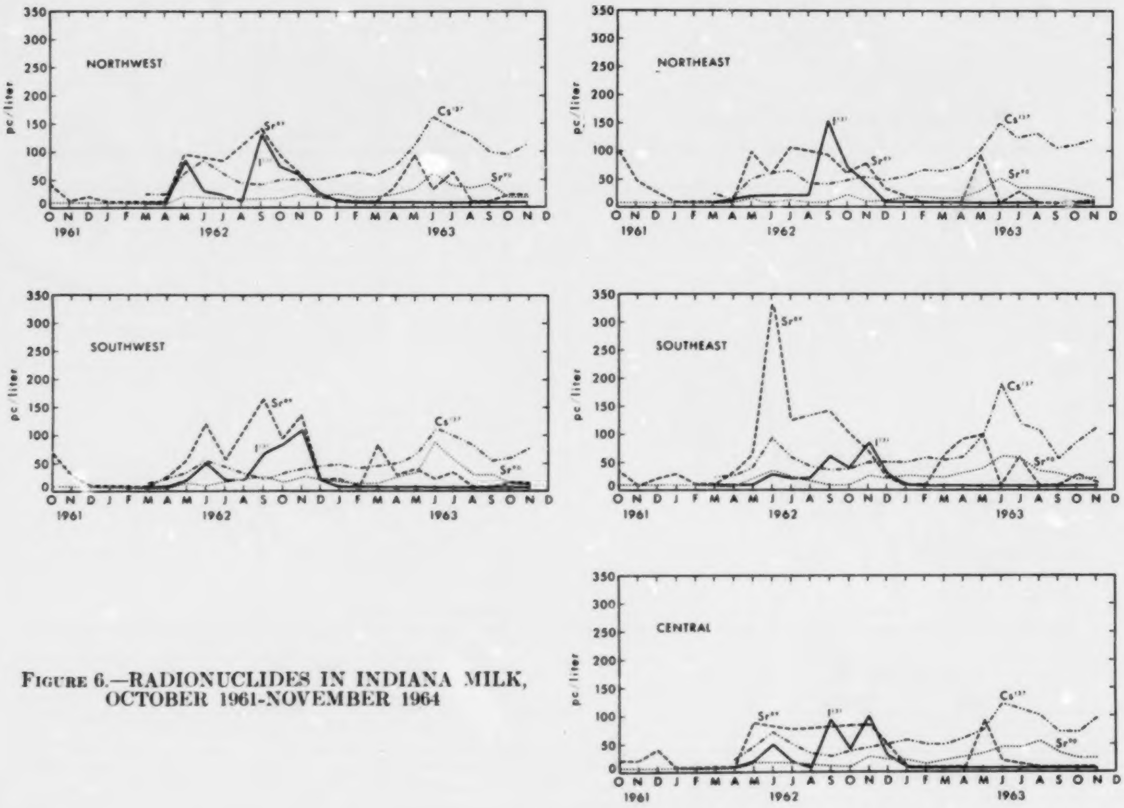


FIGURE 6.—RADIONUCLIDES IN INDIANA MILK, OCTOBER 1961-NOVEMBER 1964

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 4. The State average is an arithmetic average of the station values. Figure 6 summarizes the monthly averages of radionuclide concentrations at each station since beginning operation of the network.

TABLE 4.—RADIONUCLIDES IN INDIANA MILK, JANUARY 1964[a]

[Concentrations in pc/liter]

Sampling location	Ca (g/liter)	K^{40}	Sr^{90}	Cs^{137}	Ba^{140}
Northeast	1.15	1280	27	125	0
Southeast	1.18	1260	21	115	10
Central	1.18	1290	25	115	0
Southwest	1.13	1290	29	125	0
Northwest	1.18	1290	25	130	0
State average	1.16	1280	25	120	0

[a] The monthly average iodine-131 and strontium-89 concentration at each station was zero.

3. Washington Milk Network,[1] December 1962—December 1963

Air Sanitation and Radiation Control Section
State of Washington Department of Health

The Washington State Department of Health initiated a surveillance program for radioactivity in raw milk in December 1962. Ten collection points, shown in figure 7, were selected to provide samples representative of varying climatological conditions within the State's two major milksheds. As this sampling program also provides representation of a large percentage of the population's milk supply in the State, it would provide a basis for initiating countermeasures. Milk from Northwest Idaho (Sandpoint) is included in the network as this area forms a part of the Spokane milkshed. Several additional points are sampled from time to time.

Raw milk samples are collected routinely approximately every two weeks from individual tankers but the sampling frequency is flexible. Increased sampling can be initiated immediately if the need should arise.

Analytical Procedures

All milk samples are gamma scanned for 100 minutes in a 2-liter stainless steel Marinelli beaker. This beaker, which is placed on a 3" x 3" NaI (T1) crystal, provides equal sample thickness on all sides and top of the crystal. The spectra are recorded with a 512-channel analyzer. A 4" x 4" matrix is used to analyze the spectra and provide rapid quantitative results for iodine-131, barium-140, cesium-137, and potassium-40.

An 800-minute background count is taken once each week. In order to check the stability of the analyzer, a one-minute count each day of a cesium-137 standard (solid) is done as an efficiency check, and a ten-minute count each week of the same source is done as a check on

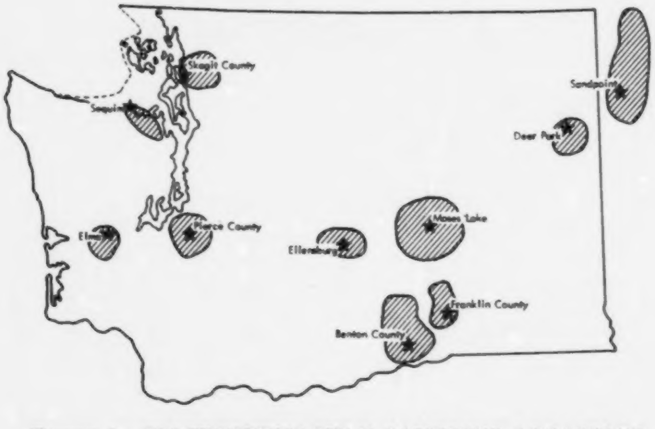


FIGURE 7.—WASHINGTON MILK SAMPLING LOCATIONS

resolution. These counts must fall within two standard deviations of the average for the analyzer to be considered to be working normally. Table 5 gives the gamma efficiencies and detectability limits for this system.

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[1] Data from *Environmental Radiation Surveillance in Washington State*, Second Annual Report, August 1963 and Monthly Surveillance Reports, *Radioactivity in Milk*.

TABLE 5.—BETA AND GAMMA EFFICIENCIES AND LIMITS OF DETECTABILITY

	Energy band (Mev)	Efficiency (%)	Average background [a] (pc)	Limits of detectability (pc)
Gamma				
K^{40}	1.37–1.55	0.18	2277	325
I^{131}	0.33–0.40	4.20	300	20
Cs^{137}	0.62–0.72	2.60	246	30
Ba^{140}	0.46–0.57	3.50	326	30
Beta				
Y^{90}	—	70	8.0	1.7

[a] Counts per minute expressed as pc.

Following gamma scanning, selected samples are analyzed for strontium–90. After the addition of strontium carrier, the milk proteins are precipitated with trichloracetic acid. Oxalic acid is then added to the sample to precipitate the alkaline earths as oxalates (pH 3.0). The oxalates are ashed, dissolved in 6 *N* hydrochloric acid, and the pH is adjusted to 1.4 to dissolve the ash. A double extraction using an equal volume of 20 percent di-(2-ethylhexyl) phosphoric acid (HDEHP) in toluene is performed. This effectively removes rare-earth activity, including yttrium–90, leaving the strontium–90 in the sample. This sample is stored a minimum of two weeks to allow yttrium–90 to ingrow. Subsequently, the yttrium–90 is extracted with 5 percent HDEHP in toluene solution. The organic layer is scrubbed with an HC1 solution (pH 1.4) and back extracted with 3N HNO_3. The resulting nitric acid solution is evaporated and yttrium–90 count from which the strontium–90 activity is calculated.

The yttrium–90 counting is done in a gas flow internal proportional counter. The efficiency and detectability limits are shown in table 5.

In addition to the solvent extraction method which is used for routine analysis of strontium–90, an ion exchange method has recently been used. Where available, the results from both methods have been averaged and are presented in table 6.

As a part of the laboratory's quality control program some samples are split and analyzed several times. Split samples are also exchanged with State, Federal and university laboratories for analyses and comparisons.

TABLE 6.—RADIONUCLIDE CONCENTRATIONS IN WASHINGTON MILK

[Concentrations in pc/liter]

	Potassium-40													Strontium-90						
	1962	1963												1962	1963					
	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June
Benton Co.			1252	1025	1282	1265	1200	967	1074	1156		1437				8			17	
Deer Park	1208	1328	1240	1048	1274	1173	1235	1243	1236	1211	1215	1193	1327	11	14		26		35	35
Ellensburg	1335	1164	1159	1196											8		8			
Elma	1280	1354	1226	1189	1188	1197	1232	1277	1290	1323	1250	1268	1282	9		10			32	
Franklin Co.			1240	1189	1173		1303	1193	1290		1338		1434			9				6
Moses Lake	1266	1195	1319	1233	1243	1159	1474	1230	1244	1217	1255	1227	1273		5		<2		14	5
Pierce Co.	1222	1253	1585	1273	1236	1269	1244	1285	1362	1208	1263	1297	1457		7		7			22
Sandpoint, Idaho	1188	1295	1151	1129		1249	1225	1284	1272	1257	1195	1399	1270	15	20		17		46	44
Sequim	1069	1254	1204	1197	1264	1293	1245	1238	1161	1176	1308	1279	1219		2		10		22	
Skagit Co.	1191	1192	1206	1146	1171	1222	1137	1281	1226	1240	1158	1312	1378		8		14			24

	Strontium-90-Continued						Iodine-131 [a]	Cesium-137													Ba^{140}
	1963						1962	62	1963												62 [b]
	July	Aug.	Sep.	Oct.	Nov.	Dec.	Dec.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	Dec.
Benton Co.	27	11	20		16					40	51	66	134	78	166	77	86		88		
Deer Park	28	12	26	31	35	29	<10	82	93	63	78	106	169	171	205	172	156	145	170	161	<15
Ellensburg							<10	68	67	72	67										<15
Elma	17		46	33	23	15	<10	58	49	46	49	60	103	194	155	174	186	178	112	72	<15
Franklin Co.		12								50	38	177		64	114	78		50		77	
Moses Lake	13	12	12	12	14		<10	68	36	46	46	67	75	44	126	79	83	79	88	89	<15
Pierce Co.	30		52	21		20	29	80	71	81	63	172	274	164	228	285	324	149	209	123	27
Sandpoint, Idaho	50	32	46	51	59	51	<10	103	112	105	107		202	248	451	308	298	276	305	318	<15
Sequim		21		31		22	<10	67	97	58	77	83	65	98	243	111	142	260	186	158	<15
Skagit Co.	15	39		22	24	22	20	84	75	71	69	83	128	139	166	216	170	231	195	199	<15

[a] All I^{131} monthly averages when samples were taken during 1963 were <10.

[b] All Ba^{140} monthly averages when samples were taken during 1963 were <15. Exception: In June 1963 the Sequim average was 13 and the Skagit average was 21.

Results

Table 6 presents the monthly average radionuclide content of raw milk for ten of the production areas in the major milksheds. Iodine-131 and barium-140 have in general been nondetectable in 1963. For both cesium-137 and strontium-90 the Sandpoint production area had somewhat higher concentrations than the other areas during the period reported. Benton, Franklin, and Moses Lake have usually had the lower monthly averages.

4. Canadian Milk Network,[2] January 1964

Radiation Protection Division
Department of National Health and Welfare,
Ottawa, Canada

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 8) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station, samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, strontium-89, cesium-137, and stable potassium and calcium.

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*3*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodine ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine-131 determined by comparison with standard preparations.

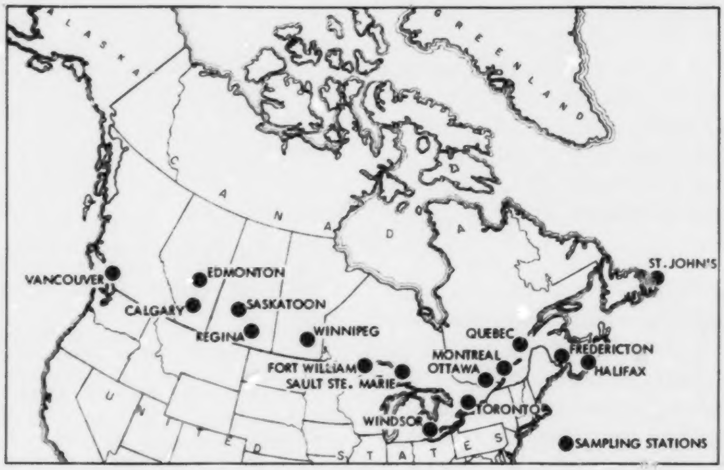

FIGURE 8.—CANADIAN MILK SAMPLING STATIONS

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[2] Data from *Radiation Protection Programs, Vol. 2, No. 2*, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (February 1964).

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450°C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium–89 and strontium–90 are determined by counting in a low background beta counter. Strontium–90 is determined separately by extracting and counting the yttrium-90 daughter nuclide while strontium–89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium–137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium–40 and cesium–137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium–40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radioisotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors estimated on the basis indicated above, are given in table 7.

TABLE 7.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK [a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

Results

Table 8 presents monthly averages of strontium–89, strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 indicate that all samples had <5 pc/liter.

TABLE 8.—RADIONUCLIDES IN CANADIAN WHOLE MILK, JANUARY 1964

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.31	1.5	50.6	299
Edmonton	1.29	1.6	39.2	232
Ft. William	1.23	1.7	57.4	299
Fredericton	1.29	1.6	56.6	378
Halifax	1.30	1.7	41.2	279
Montreal	1.25	1.7	44.3	285
Ottawa	1.27	1.7	30.1	232
Quebec	1.21	1.6	56.0	239
Regina	1.24	1.6	54.7	216
St. John's, Nfld	1.21	1.5	38.6	262
Saskatoon	1.28	1.7	59.0	242
Sault Ste. Marie	1.26	1.6	42.0	224
Toronto	1.32	1.6	20.0	141
Vancouver	1.38	1.7	32.9	266
Windsor	1.27	1.6	19.9	118
Winnipeg	1.20	1.7	46.5	249
Average	1.27	1.6	43.1	254

REFERENCES

(*1*) Public Health Service: Summary of Results from the Raw Milk Sampling Program, June 1957-April 1963, *Radiological Health Data*, *4*:511-23 (October 1963).

(*2*) Porter, C., D. Cahill, R. Schneider, P. Robbins, W. Perry, and B. Kahn: Determination of Strontium-90 in Milk by an Ion Exchange Method, *Analytical Chemistry*, *33*:1306-8 (September 1961).

(*3*) DasGupta, A. K., and H. G. Green: *A Method for the Radiochemical Determination of Iodine-131 in Milk, RPD-23*, Radiation Protection Division, Department of National Health and Welfare, Ottawa, Canada (October 1963).

MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1963-JANUARY 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to assess the contribution of milk to an individual's or a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of an individual or a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all foods. The upper limits of intake Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one-third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). However, the FRC emphasizes that the annual acceptable risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*). The ICRP has set the maximum permissible concentration (MPC) for cesium–137 in water for the population at large equal to 2000 pc/liter (*7*). This MPC may be applied to milk if it is assumed that all food would be contaminated to the same extent.

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks ending in twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are due to a number of combined causes. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

REFERENCES

(*1*) Public Health Service: Milk Surveillance—Pasteurized Milk Network, *Radiological Health Data*, *5*:57 (February 1964).

(*2*) Bureau of the Census, and Public Health Service: National Food Consumption Survey, Fresh Whole Milk Consumption in the United States, July 1962, *Radiological Health Data* *4*:15-17 (January 1963).

(*3*) Bureau of the Census and Public Health Service: Consumption of Selected Food Items in U. S. Households, July 1962, *Radiological Health Data*, *4*:124-7 (March 1963).

(*4*) Federal Radiation Council: Radiation Protection Guidance for Federal Agencies, *Federal Register*, Superintendent of Documents, Government Printing Office, Washington, D. C. 20402 (September 26, 1961).

(*5*) Federal Radiation Council: *Background Material for the Development of Radiation Protection Standards, Report No. 2*, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402 (September 1961), price 20 cents.

(*6*) Public Health Service: Special Report, *Radiological Health Data*, *3*:ii-iii (September 1962).

(*7*) International Commission on Radiological Protection: *Report of Committee II on Permissible Dose for Internal Radiation*, Pergamon Press, New York (1959).

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[1] Beginning with the October 1963 data, iodine-131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

Table 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK[a]

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		January 1963 December 1963	February 1963 January 1964	January 1963 December 1963	February 1963 January 1964	January 1963 December 1963	February 1963 January 1964	January 1963 December 1963	February 1963 January 1964
Ala:	Montgomery	59	53	21	21	4	3	76	80
Alaska:	Palmer	30	29	21	22	5	3	117	123
Ariz:	Phoenix	12	11	4	4	4	3	22	22
Ark:	Little Rock	111	101	42	43	8	5	148	154
Calif:	Sacramento	38	37	10	10	6	3	58	61
	San Francisco	71	67	13	14	5	3	70	74
Colo:	Denver	26	25	16	17	6	5	83	84
Conn:	Hartford	21	21	23	24	4	3	143	152
Del:	Wilmington	28	27	25	25	4	4	121	127
D. C:	Washington	38	37	19	20	4	3	92	96
Fla:	Tampa	30	28	14	14	6	5	215	221
Ga:	Atlanta	83	76	29	30	5	4	137	142
Hawaii:	Honolulu	34	31	10	11	6	5	73	75
Idaho:	Idaho Falls	43	49	23	24	5	3	131	140
Ill:	Chicago	18	18	20	21	4	3	101	107
Ind:	Indianapolis	28	28	23	23	4	3	93	97
Iowa:	Des Moines	57	56	24	25	5	3	87	91
Kans:	Wichita	41	39	19	19	5	3	70	72
Ky:	Louisville	84	82	32	32	4	3	102	108
La:	New Orleans	135	123	42	43	8	7	147	154
Maine:	Portland	26	26	30	31	4	3	191	200
Md:	Baltimore	46	46	21	21	4	3	116	119
Mass:	Boston	31	31	33	34	4	3	206	219
Mich:	Detroit	16	16	20	20	4	3	105	110
	Grand Rapids	18	17	20	20	5	4	110	115
Minn:	Minneapolis	48	47	29	30	5	3	142	148
Miss:	Jackson	127	115	35	36	7	5	108	113
Mo:	Kansas City	65	63	26	27	4	3	78	83
	St. Louis	47	46	21	22	5	3	82	85
Mont:	Helena	46	45	26	27	5	4	160	171
Nebr:	Omaha	49	47	24	25	5	3	92	95
Nev:	Las Vegas	17	17	8	9	4	4	65	69
N. H:	Manchester	29	29	32	33	5	5	230	242
N. J:	Trenton	21	21	21	21	4	3	113	119
N. Mex:	Albuquerque	21	19	9	10	4	3	41	43
N. Y:	Buffalo	21	21	22	23	4	3	128	133
	New York	29	29	28	29	4	3	147	156
	Syracuse	24	24	23	23	4	4	122	130
N. C:	Charlotte	65	63	31	31	4	3	114	119
N. Dak:	Minot	82	81	47	50	5	4	130	136
Ohio:	Cincinnati	35	34	25	26	5	4	84	89
	Cleveland	23	23	21	21	4	3	100	105
Okla:	Oklahoma City	62	58	23	23	6	4	85	87
Ore:	Portland	71	67	28	29	4	3	150	157
Pa:	Philadelphia	26	25	23	24	4	3	115	120
	Pittsburgh	33	33	28	29	4	4	137	144
P. R:	San Juan	69	57	14	14	8	6	88	88
R. I:	Providence	26	25	26	27	4	4	151	159
S. C:	Charleston	63	59	26	27	6	5	118	123
S. Dak:	Rapid City	65	64	35	37	5	4	139	147
Tenn:	Chattanooga	100	95	36	37	4	3	133	140
	Memphis	87	80	31	31	5	3	84	88
Tex:	Austin	30	25	9	9	6	3	44	45
	Dallas	68	58	21	21	7	5	78	80
Utah:	Salt Lake City	33	32	22	23	6	5	145	153
Vt:	Burlington	25	25	27	28	4	3	161	171
Va:	Norfolk	45	43	22	22	4	3	97	100
Wash:	Seattle	56	53	24	25	5	3	145	149
	Spokane	49	49	25	27	5	4	132	137
W. Va:	Charleston	65	64	29	29	4	4	93	98
Wis:	Milwaukee	18	18	18	19	4	4	106	113
Wyo:	Laramie	38	37	21	21	4	3	115	115
Network average		47	45	23.7	24.4	5	4	114	119

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[a] Annual averages were computed on the basis of 52 weekly averages.

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STRONTIUM-90 IN 1963 HARVEST OF SELECTED GRAINS—PRELIMINARY REPORT

Division of Pharmacology, Food and Drug Administration

Because of the finding in 1963 of elevated levels of strontium-90 in wheat harvested mainly in Kansas, it was decided to study the impact of 1963 fallout on wheat and other grains in more detail. Table 1 lists preliminary analytical results for barley, oats, rye, and wheat by States where data are available for both 1962 and 1963.

Even though this is a preliminary survey with all analytical results on the 1963 harvest not yet available, it is clear that there have been substantial increases in the strontium-90 concentrations in these four grains. Also, with few exceptions, individual 1963 results range higher than their 1962 counterparts.

TABLE 1.—PRELIMINARY 1963 STRONTIUM-90 RESULTS FOR SELECTED GRAINS COMPARED WITH 1962 RESULTS

State	Barley				Oats				Rye				Wheat					
	1962		1963		1962		1963		1962		1963		1962			1963		
														Sr^{90} (pc/kg)			Sr^{90} (pc/kg)	
	No. of samples	Sr^{90} (pc/kg)	No. of samples	Sr^{90} (pc/kg)	No. of samples	Sr^{90} (pc/kg)	No. of samples	Sr^{90} (pc/kg)	No. of samples	Sr^{90} (pc/kg)	No. of samples	Sr^{90} (pc/kg)	No. of samples	average	range	No. of samples	average	range
Ala.	1	104	2	325														
Calif.	[a]				4	12	1	10										
Colo.	2	19	2	79					1	30	1	55	4	66	11-135	1	365	—
Ga.					2	131	1	44										
Idaho	1	2.9	1	65	1	15	1	184					5	16	4.6-34	1	53	
Ill.													9	80	9.0-158	1	114	
Ind.					1	82	1	309					4	74	53-90	9	180	50-453
Kans.					3	65	1	193					9	46	6.8-92	18	779	73-1340
Ky.	2	88	1	359														
Md.					1	48	1	127	1	9	2	47						
Mich.					1	97	1	216					3	81	36-159	6	230	20-509
Miss.													5	144	76-241	5	127	108-143
Mo.	1	73	2	389					1	124	2	242	3	32	16-40	2	202	189-215
Nebr.									1	179	1	518	4	144	48-271	2	249	19-478
N. J.													1	16		1	158	
N. C.													2	99	72-126	1	120	
N. D.	2	81	2	49														
Ohio					1	84	1	127	1	58	3	224	5	63	47-103	14	116	4.0-242
Ore.	1	22	1	62	2	13	1	92					1	16		1	64	
Pa.	2	68	1	626					1	31	1	69	4	41	35-48	1	160	
S. C.					1	167	2	393	1	168	2	147	3	119	106-134	3	167	17-289
Tex.													8	94	15-182	3	341	209-604
Utah									1	28	1	95	2	28	27-28	2	25	6.8-44
Va.													2	77	67-87	4	103	24-136
W. Va.					1	90	1	132										
Wyo.													3	49	8.9-97	1	192	

[a] Blank indicates no data available.

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STRONTIUM-90 IN FOODS AT INTERMEDIATE STAGES OF PREPARATION FOR CANNING AND FREEZING

Division of Pharmacology, Food and Drug Administration

For the past few years, the Food and Drug Administration (FDA) has conducted an extensive surveillance program on radioactivity in domestic and imported foods (*1*). This program has been largely directed at assessing the degree of radioactive contamination (including strontium–90) in individual foods, and the total diet. In addition, considerable attention has also been focused on commercial processing of foods in an attempt to learn what effects such operations have on removing radioactive contamination. Presented below are the results of FDA studies on the effect of individual processing steps on the strontium–90 content of foods. These studies were done in collaboration with the National Canners Association and the Association of Frozen Food Packers.

Canned Fruits and Vegetables

Studies were conducted on peaches, tomatoes, and snap beans to determine what effect typical food preparative procedures, conducted prior to canning would have on the strontium–90 content of these foods. The preparative procedures consisted of (1) chemical removal of peach skins, (2) mechanical removal of tomato skins and cores, and (3) washing and blanching of snap beans. The products were harvested in August 1962 and processed in an experimental pilot plant of the National Canners Association at Berkeley, California. The determination of strontium–90 and stable strontium on the various processed segments was done in the FDA laboratories in Washington, D C. Strontium–90 was analyzed following the method of Harley (*2*) and stable strontium was analyzed by a standard X-ray fluorescence method (*3*).

Peaches

The distribution of strontium–90 in raw peaches was studied both before and after peeling. Peeling of the halved and pitted fruit was done with hot (218°F) two percent lye solution. Fresh water spray rinsing followed the peeling step.

Results: The removal of peach skins resulted in a significant reduction of strontium–90 in the peach, as shown in table 1. Since the peeling losses were recorded for each lot, the strontium–90 content of the peel could be calculated. The results showed that a comparatively sizable burden of strontium–90 must occur in this portion of the fruit. A pooled sample of peach pits was also analyzed; this portion of the fruit had a concentration of 1.1 pc/kg, about the same as the flesh.

Because of the limited number of stable strontium analyses and their variability, little information can be deduced from these data. However, it may be observed that the concentration of stable strontium tends to be higher in the peeled peach than in the whole peach.

TABLE 1.—EFFECT OF PEELING ON THE STABLE STRONTIUM AND STRONTIUM-90 CONTENT OF PITTED PEACHES

Type	Sample number	Unpeeled		Peeled		Difference	Skins	
		Sr^{90} (pc/kg)	Stable strontium (μg/kg)	Sr^{90} (pc/kg)	Stable strontium (μg/kg)	Sr^{90} content (pc/kg)	Portion of whole fruit (percent)	Calculated Sr^{90} (pc/kg)
Cling	85-479	1.5	34		47		7.6	
	85-475	2.5		1.9		0.6	8.2	7.3
	85-477	3.4	83	2.1	123	1.3	11	12
	85-473	2.5		0.8		1.7	9.9	17
	85-481	2.7		1.1		1.6	6.1	26
	85-483	3.9	92	0.8		3.1	6.2	50
	85-493	3.7		1.4		2.3	5.1	45
	85-491	1.1		0.6		0.5	5.5	9
	85-489	1.9	112	0.1	191	1.8	5.9	31
Freestone	85-485	2.5	132		136		4.2	
	85-487	2.5	60	1.7	37	0.8	6.7	12
Average Sr^{90} content (pc/kg)		[a] 2.6		[a] 1.2				
Average stable strontium content (μg/kg)			85		107			

[a] Significance: 2.6 *vs.* 1.2 $p = 0.001$

Snap Beans

Strontium–90 was similarly investigated in raw and unwashed, washed and blanched, and in heat-processed beans. Washing was done in warm (80°F) 0.05 percent detergent solution, followed by a fresh water rinse. This was followed by an 8 to 10 minute blanching in water at 205°F. Finally, the blanched beans were heat-processed at 250°F for 15 minutes.

Results: The strontium–90 content of snap beans following these three preparative procedures given in table 2 shows that the combined washing and blanching process removed strontium–90 from the raw bean (1.8 pc/kg *vs.* 0.89 pc/kg, $p = 0.15$). While the difference was not statistically significant at the 95 percent level of confidence, nevertheless, a trend is suggested. Inspection of the data also showed that there was no difference between washed and blanched and heat-processed beans. Stable strontium data disclosed no significant difference between the three treatments. Variations noted are ascribed to random analytical errors inherent in the method. Assuming that the stable strontium which occurs within the tissues of the plant is not labile, such a finding could be expected, since only the surface strontium would be removed. Furthermore, the reduction of the Sr^{90} to stable strontium ratio in beans between the steps from raw to washed and blanched was interpreted to be due to removal of strontium–90 from the surface and not from internal structures.

Tomatoes

The experimental processing of tomatoes to study the distribution of strontium–90 was done on whole, unwashed, unpeeled tomatoes; whole, washed, unpeeled tomatoes; peeled and cored tomatoes; and waste residue, comprising peels and cores.

Washing was done with warm (80 F) 0.05 percent commercial detergent solution to which was added 8 percent sodium dodecylbenzenesulfonate. The detergent solution was recirculated through five pairs of narrow-angle, flat-jet nozzles at 10 psi, equivalent to a total of 10 gallons per minute of recirculated solution. Following the wash, the tomatoes were rinsed twice. The first rinse was at 80°F, and the second at 60°F. Peeling and coring was done by hand after the fruit had been immersed for three minutes in 205°F water.

Results: The strontium–90 content of the five segments is given in table 3. The strontium-90 concentration in tomatoes is low and presents certain analytical difficulties. The results, however, were interpreted as follows: there was no difference in strontium–90 content of washed and unwashed tomatoes, and peeling and coring removed strontium–90 (0.64 pc/kg *vs.* 0.39 pc/kg, $p = 0.25$). Although the difference was not significant at the 5 percent level, a trend was nevertheless indicated. Coring accounted for the removal of strontium–90

TABLE 2.—EFFECT OF PROCESSING ON THE STRONTIUM-90 CONTENT OF SNAP BEANS

Sample number	Raw Beans			Washed and Blanched			Heat Processed		
	Sr^{90} (pc/kg)	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)	Sr^{90} (pc/kg)	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)	Sr^{90} (pc/kg)	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)
85–421	0.10	194	0.052x10	0.67			0.77	165	$0.47x10^{-2}$
85–422	3.6	196	1.8 x10	0.39	174	$0.22x10^{-2}$	0.89	168	$0.53x10^{-2}$
85–424	0.14	205	0.068x10	0.17	209	$0.08x10^{-2}$	0.21	175	$0.12x10^{-2}$
85–425	4.5	189	2.38 x10	2.8	219	$1.28x10^{-2}$	2.2	263	$0.84x10^{-2}$
85–427	1.7			0.88	116	$0.76x10^{-2}$	0.58	159	$0.36x10^{-2}$
85–428	0.21	104	0.20 x10	0.0	118		0.09		
85–430	2.1	134	1.57 x10	0.73	145	$0.50x10^{-2}$	1.0	125	$0.80x10^{-2}$
85–431		104			133			148	
85–433	3.3			3.2	219	$1.46x10^{-2}$	2.1	270	$0.78x10^{-2}$
85–434	2.8	203	1.38 x10	0.09	223	$0.04x10^{-2}$	0.22	206	$0.11x10^{-2}$
85–435	0.84			0.57			0.50	256	$0.20x10^{-2}$
84–436	1.1	309	0.36 x10	0.39	297	$0.13x10^{-2}$	0.40	314	$0.13x10^{-2}$
Average Sr^{90} content (pc/kg)	[a] 1.8			[a] 0.89			0.82		
Average stable strontium content (µg/kg)		182	0.99 x10		205	$0.43x10^{-2}$		204	$0.40x10^{-2}$ a.

[a] Significance: 1.8 *vs.* 0.89 $p=0.15$

TABLE 3.—EFFECT OF PROCESSING ON THE STRONTIUM-90 CONTENT OF TOMATOES

Sample number	Whole	Washed Whole		Peeled and Cored		Peels		Cores
	Sr^{90} (pc/kg)	Sr^{90} (pc/kg)	Stable strontium (μg/kg)	Sr^{90} (pc/kg)	Stable strontium (μg/kg)	Sr^{90} (pc/kg)	Stable strontium (μg/kg)	Sr^{90} (pc/kg)
84-798	0.32	0.43		0.37		0.07		0.78
85-411	0.37	0.19		0.52				0.59
85-405	0.77	0.81		1.0		0.07		1.7
85-409	1.4	0.38		0.74				0.49
85-407	0.10	0.07		0.04		1.4		1.6
85-403	0.12	3.0	85	0.41	92	0.08		0.43
85-401	0.50	0.57		0.34	91	0.10	78	0.83
85-419	0.60		24	0.29		0.96	0	0.90
85-417	0.49	0.49		0.20	120	0.23	89	0.43
85-415	0.55	0.39		0.48	38	1.4		2.2
85-413	0.51	0.63			140	1.0		1.3
84-796	1.0	0.15		0.35		0.87		
Average Sr^{90} concentration (pc/kg)	0.56	[a, b] 0.64		[a] 0.39		0.62		[b] 1.02
Average stable strontium concentration (μg/kg)			55		96		84	

[a] Significance 0.64 *vs.* 0.39, p=0.25
[b] Significance 0.64 *vs.* 1.02, p=0.25

(0.64 pc/kg *vs.* 1.02 pc/kg, p = 0.25). Again this was interpreted as indicating a trend. Strontium-90 contamination seemed to be accounted for only by the core and not by the peel. The data did not warrant a deduction as to whether the strontium-90 content of the core resided internally or at the surface of the blossom and stem ends of the fruit. Because of the analytical limitations of the X-ray fluorescence method for determining stable strontium at the low levels found in tomatoes, too few analyses are reported to permit evaluation.

Frozen Vegetables

Experiments were conducted in the fall of 1962 to determine the effects of commercial freezing operations on the distribution of strontium-90 in plant parts. Broccoli and spinach were selected because their surface textures offered good opportunities for entrapment and retention of atmospheric fallout. With respect to distribution of fallout, it is of interest to note that more strontium-90 was found on broccoli leaves than on the flower portion—contrary to what might have been expected on the basis of surface area as a criterion.

Broccoli

Broccoli was harvested in Maryland on September 26, 1962 from three areas of a planting consisting of 118 rows. Four types of raw unprocessed samples were taken: five-inch heads with some preliminary trimmings, six-inch heads with large coarse leaves removed, side shoots, and leaf trimmings. Two types of frozen broccoli, pooled from the raw samples and processed at a local packer, were broccoli spears and chopped broccoli which consisted mostly of leaf trimmings and portions of heads and spears. The results of the analyses for strontium-90 are given in table 4.

TABLE 4.—DISTRIBUTION OF STRONTIUM-90 ON BROCCOLI

Sample	Sampling area (kg)	Strontium-90 content (pc/kg)
5-inch head	*Harvest Area Number 1*	40
6-inch head		38
Leaves		215
5-inch head	*Harvest Area Number 2*	42
Side shoots		15
Leaves		120
5-inch head	*Harvest Area Number 3*	52
6-inch head		29
Side shoots		14
Leaves		136
Chopped, frozen	*Processed Broccoli pooled from all areas*	28
Spears		2.7

Essentially there were no significant differences in strontium-90 concentrations between the five-inch and six-inch heads taken from three areas. Two samples of side shoots contained substantially less strontium-90—a finding that might be explained by the fact that the side shoots are perhaps not as fully exposed to fallout as the heads. In contrast, leaves showed by far the highest strontium-90 concentration in any of the raw samples analyzed. Processing, such as washing and blanching preliminary to freezing, removed a considerable amount of surface strontium-90. This is shown clearly in the chopped samples, which are made up largely of leafy parts, and the spears. The difference between these processed samples was most readily explained by noting the differences observed in the raw product.

A substantial difference was observed in the distribution of strontium-90 between at least three edible portions of the broccoli plant; these differences were carried over to the frozen product. Each product (spears and chopped) lost over 80 percent of its original strontium-90 content during processing.

Consideration of climate caused variations in the distribution of strontium-90 in broccoli parts are beyond the scope of these studies.

Spinach

The spinach was harvested from six areas at a farm in New Jersey and was processed at a food packing plant. Four points on the processing production line were sampled, representing: unwashed spinach, washed spinach, blanched spinach, and cooled spinach. The last-named was equivalent to the frozen, commercially-packaged product.

Analyses were made for strontium-90 and for stable strontium. Results are given in table 5. With respect to strontium-90, the experiments indicated that the largest removal of this isotope occurred in the blanching process and not in the washing processes. This was interpreted to mean that a substantial part of the surface contamination of spinach is protected from removal by successive layers of wax cover left undisturbed by cold water washing. When these wax layers were stripped by blanching, the strontium-90 so uncovered was free to be removed by the hot water. As expected, no significant change in the strontium-90 level occurred when the blanched spinach was cooled prior to packaging and freezing.

With respect to stable strontium, the findings were interpreted as being indicative of *no* changes in its distribution during processing. Variations noted must be ascribed to random analytical errors inherent in the method.

Specific activities have been calculated for each treatment, i.e. pc Sr^{90}/µg stable strontium. The decrease in the ratio through the washing and blanching steps of the treatment showed

TABLE 5.—EFFECT OF PROCESSING ON STABLE STRONTIUM AND STRONTIUM-90 CONTENT OF SPINACH

Lot No. and (harvest date)	Unwashed			Washed			Blanched			Cooled		
	Sr^{90} pc/kg	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)	Sr^{90} (pc/kg)	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)	Sr^{90} (pc/kg)	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)	Sr^{90} (pc/kg)	Stable strontium (µg/kg)	Sr^{90}/stable strontium (pc/µg)
3-517 (10-11-62)	58	164	0.35	38	117	0.33	29	116	0.25	33	146	0.23
2-521 (10-11-62)	117	133	0.87	108	107	1.0	67	111	0.60	68	136	0.50
3-511 (10-16-62)	92	192	0.48	83	236	0.35	57	206	0.28	63	252	0.25
1-527 (10-16-62)	70	193	0.36	70	266	0.26	58	170	0.34	70	209	0.34
1-501 (10-25-62)	66	172	0.38	59	288	0.21	38	246	0.15	31	225	0.14
1-509 (10-26-62)	86	90	0.95	79	107	0.74	57	129	0.44	62	129	0.48
Average Sr^{90} concentration (pc/kg)	81			[a] 73			[a] 51			54		
Average stable strontium concentration (µg/kg)		157			187			163			182	
Average Sr^{90}/stable strontium ratio			0.57			0.48			0.34			0.32

[a] Significance: 73 vs 51, p=0.02

removal of strontium–90, which must have been from the surface and not from internal structures. Otherwise a systematic decrease of stable strontium levels would also have been noted. Stable strontium occurs only in the internal parts of the spinach plant by translocation from the soil, while strontium–90 results from direct deposition of fallout as well as translocation from the soil.

REFERENCES

(1) Food and Drug Administration: Survey of Radioactivity in Food, *Radiological Health Data*, 3:476-81 (December 1962).

(2) U. S. Atomic Energy Commission, New York Operations Office: *Health and Safety Laboratory Manual of Standard Procedures, NYO-4700:* Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C. (February 1960) price $1.75.

(3) Liebhafsky, H. A., H. G. Pfeiffer, E. H. Winslow, and P. D. Zemany: *X-Ray Absorption and Emission in Analytical Chemistry*, John Wiley and Sons, Inc., New York (1960).

Correction for April 1964 Issue

A portion of the first paragraph in the "PROCEDURES" section, page 181, April *RHD* article, "Radionuclides in Diets for Teenagers, May 1962—November 1963," was omitted in error. The correct version reads as follows:

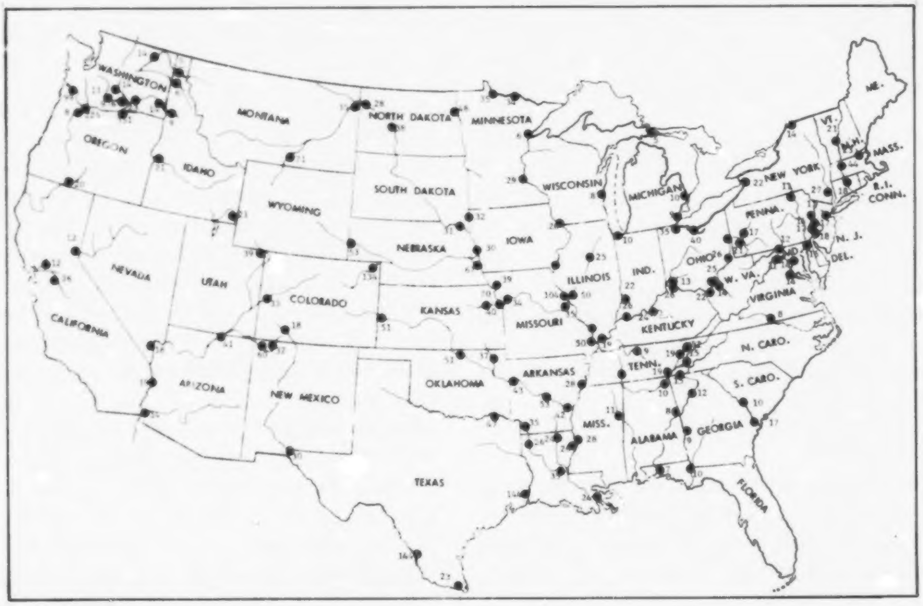
To duplicate the diet of a 19-year old male, a list of 82 different items of food and drink was prepared. Quarterly samples of these items, covering a two-week consumption period, were purchased from national food chain stores. Efforts were made to locate the sources of the food items and to choose the samples for the broadest possible geographical representation.

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, NOVEMBER 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System (formerly National Water Quality Network) since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 128 stations as of April 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1–6*).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ARKANSAS
S. CARO.
MISS.
ALABAMA
GEORGIA
TEXAS
FLORIDA

FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, NOVEMBER 1963

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the PHS Robert A. Taft Sanitary Engineering Center in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Gross beta activity in each weekly sample was determined until January 1960, when the levels became essentially equal to background. Thereafter, gross beta determinations were made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations. On September 1, 1961, weekly determinations of gross beta activity again were instituted to permit early detection of activity due to fallout from renewed weapons testing. This practice was continued until the end of October 1962, when samples for gross beta analysis were again composited monthly. Gross alpha determinations were made once a month except where variable or high values observed during the first year indicated the need for more frequent measurement.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*7*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning November 1962 the frequency of strontium-90 analyses was reduced to twice a year at each sampling point except those stations immediately below nuclear installations. Until the fourth quarter of 1961, the method used for determining strontium-90 was that described in the above reference (*7*). Tributyl phosphate was used to extract ingrown yttrium-90 from the purified, coprecipitated strontium-90. Beginning with the first quarter of 1962, a modification of a procedure described by Harley has been used (*8*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background, anticoincidence, end-window proportional counter.

Results

Table 1 presents November 1963 results of alpha and beta analyses of U. S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*6*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero and when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium-90 results appeared in the January 1964 *RHD* (*9*).

TABLE 1.—RADIOACTIVITY IN U.S. SURFACE WATERS, NOVEMBER 1963 [a]

(Average concentrations in pc/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	1	16	17	0	0	0
Animas River:						
Cedar Hill, N. Mex	4	28	32	0	2	2
Apalachicola River:						
Chattahoochee, Fla	2	8	10	0	0	0
Arkansas River:						
Coolidge, Kansas	10	41	51	1	25	26
Ponca City, Okla	18	33	51	1	3	4
Fort Smith, Ark	24	19	43	1	1	2
Little Rock, Ark	8	45	53	1	2	3
Pendleton Ferry, Ark	12	30	42	1	1	2
Bear River:						
Preston, Idaho	0	21	21	0	3	3
Big Horn River:						
Hardin, Mont	38	33	71	6	10	16
Big Sioux River:						
Sioux Falls, S. Dak	2	30	32	0	7	7
Chattahoochee River:						
Atlanta, Ga	4	8	12	0	0	0
Columbus, Ga	0	9	9	0	1	1
Lanett, Ala	1	7	8	0	0	0
Chena Slough:						
Fairbanks, Alaska	1	4	5	0	0	0
Clearwater River:						
Lewiston, Idaho	2	7	9	0	0	0
Clinch River:						
Clinton, Tenn	2	17	19	0	0	0
Kingston, Tenn	3	79	82	0	1	1
Colorado River:						
Loma, Colo	11	22	33	2	11	13
Page, Ariz	4	37	41	0	10	10
Boulder City, Nev	0	18	18	0	7	7
Parker Dam, Calif-Ariz	1	18	19	0	10	10
Yuma, Ariz	0	14	14	0	2	2
Columbia River:						
Northport, Wash	1	13	14	0	1	1
Wenatchee, Wash	1	13	14	0	0	0
Pasco, Wash	85	891	976	0	1	1
McNary Dam, Ore	39	312	351	0	<1	<1
Bonneville, Ore	7	217	224	0	1	1
Clatskanie, Ore	8	91	99	0	<1	<1
Cumberland River:						
Clarksville, Tenn	1	8	9	0	0	0
Connecticut River:						
Wilder, Vt	3	18	21	0	0	0
Northfield, Mass	29	15	44	1	0	1
Enfield Dam, Conn	4	14	18	0	0	0
Cuyahoga River:						
Cleveland, Ohio	5	35	40	<1	0	<1
Delaware River:						
Martins Creek, Pa	1	10	11	0	0	0
Trenton, N. J	6	10	16	1	0	1
Philadelphia, Pa	4	13	17	0	0	0
Escambia River:						
Century, Fla	1	6	7	0	0	0
Great Lakes:						
Duluth, Minn	1	5	6	0	0	0
Sault Ste. Marie, Mich	0	5	5	0	0	0
Milwaukee, Wisc	1	7	8	0	0	0
Gary, Ind	1	9	10	0	0	0
Port Huron, Mich	1	9	10	0	0	0
Detroit, Mich	0	9	9	0	0	0
Buffalo, New York	8	14	22	0	0	0
Green River:						
Dutch John, Utah	1	38	39	0	0	0
Hudson River:						
Poughkeepsie, N. Y	2	25	27	0	0	0
Illinois River:						
Peoria, Ill	0	25	25	0	2	2
Grafton, Ill	81	23	104	4	2	6
Kanawha River: Winfield Dam, W. Va	1	13	14	0	1	1
Kansas River:						
De Soto, Kansas	34	36	70	3	2	5
Klamath River:						
Keno, Oreg	1	19	20	0	0	0
Little Miami River:						
Cincinnati, Ohio	0	13	13	0	0	0
Maumee River:						
Toledo, Ohio	14	21	35	3	1	4
Merrimack River:						
Lowell, Mass	4	19	23	0	0	0
Mississippi River:						
St. Paul, Minn	4	25	29	0	1	1
Dubuque, Iowa	1	25	26	0	1	1
Burlington, Iowa	4	24	28	0	1	1
E. St. Louis, Ill	18	32	50	0	2	2
Cape Girardeau, Mo	21	29	50	2	2	4
W. Memphis, Ark	2	26	28	0	2	2
Vicksburg, Miss	5	23	28	1	1	2
Delta, La	4	22	26	0	1	1
New Orleans, La	1	23	24	0	1	1
Missouri River:						
Williston, N. Dak	5	23	28	0	4	4
Bismarck, N. Dak	2	36	38	0	4	4
Yankton, S. Dak	0	31	31	0	5	5
Omaha, Nebr	8	22	30	1	3	4
St. Joseph, Mo	13	26	39	3	5	8
Kansas City, Kans	14	26	40	2	4	6
Missouri City, Mo	7	27	34	0	1	1
St. Louis, Mo	11	24	35	1	2	3
Monongahela River:						
Pittsburgh, Pa	0	21	21	0	1	1
North Platte River:						
Henry, Nebr	9	44	53	0	28	28
Ohio River:						
Toronto, Ohio	6	20	26	1	0	1
Addison, Ohio	3	22	25	0	0	0
Huntington, W. Va	1	21	22	0	0	0
Cincinnati, Ohio	1	25	26	0	0	0
Louisville, Ky	0	24	24	0	1	1
Evansville, Ind	2	24	26	0	0	0
Cairo, Ill	0	19	19	0	0	0
Ouachita River:						
Bastrop, La	4	20	24	0	3	3
Pend Oreille River:						
Albeni Falls Dam, Idaho	0	9	9	0	0	0
Platte River:						
Plattsmouth, Nebr	34	33	67	3	4	7
Potomac River:						
Williamsport, Md	1	11	12	0	0	0
Great Falls, Md	1	13	14	0	1	1
Washington, D.C	2	12	14	<1	0	<1
Rainy River:						
Baudette, Minn	5	30	35	0	0	0
International Falls, Minn	2	32	34	0	0	0
Raritan River:						
Perth Amboy, New Jersey (5-ft. Below Surface)	4	13	17	0	4	4
Perth Amboy, New Jersey (5-ft. Above Bottom)	1	11	12	0	4	4
Red River, North:						
Grand Forks, N. Dak	0	48	48	0	1	1
Red River, South:						
Denison, Tex	2	45	47	0	0	0
Index, Ark	2	33	35	0	0	0
Bossier City, La	1	25	26	0	1	1
Alexandria, La	2	33	35	0	1	1
Rio Grande River:						
Alamosa, Colo	4	14	18	0	0	0
El Paso, Tex	2	28	30	0	1	1
Laredo, Tex	123	21	144	19	5	24
Brownsville, Tex	3	20	23	0	1	1
Roanoke River:						
John H. Kerr Resr/Dam, Va	0	8	8	0	0	0
Sabine River:						
Ruliff, Tex	123	21	144	0	0	0
Sacramento River:						
Courtland, Calif	4	8	12	0	0	0
St. Lawrence River:						
Massena, N. Y	1	13	14	0	0	0
San Joaquin River:						
Vernalis, Calif	6	20	26	0	1	1
San Juan River:						
Shiproc[illegible] Mex	29	31	60	4	13	17
Savannah [illegible]er:						
North Augusta, S. C	1	9	10	0	0	0
Port Wentworth, Ga	3	14	17	0	0	0
Schuylkill River:						
Philadelphia, Pa	1	17	18	0	0	0
Shenandoah River:						
Berryville, Va	1	10	11	0	1	1
Ship Creek:						
Anchorage, Alaska	0	4	4	0	0	0
Snake River:						
Ice Harbor Dam, Wash	1	13	14	0	3	3
Wawawai, Wash	9	14	23	0	3	3
Payette, Idaho	2	19	21	0	5	5
South Platte River:						
Julesburg, Colo	35	99	134	3	31	34
Spokane River:						
Post Falls, Idaho	0	6	6	0	0	0
Susquehanna River:						
Sayre, Pa	2	9	11	1	1	2
Conowingo, Md	0	16	16	0	0	0
Tennessee River:						
Lenoir City, Tenn	1	14	15	0	0	0
Chattanooga, Tenn	2	13	15	0	0	0
Bridgeport, Ala	0	10	10	0	0	0
Pickwick Landing, Tenn	3	16	19	0	0	0
Tombigbee River:						
Columbus, Miss	3	8	11	1	0	1
Truckee River:						
Farad, Calif	3	9	12	0	0	0
Verdigris River:						
Nowata, Okla	0	37	37	0	0	0
Wabash River:						
New Harmony, Ind	7	15	22	1	1	2
Willamette River:						
Portland, Oreg	2	6	8	0	0	0
Yakima River:						
Richland, Wash	0	11	11	0	3	3
Yellowstone River:						
Sidney, Mont	11	24	35	1	2	3
Maximum	123	891	976	19	31	34
Minimum	0	4	4	0	0	0

[a] These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the Network's *Annual Compilation of Data* (6).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the November 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al* (*10*).

Discussion

The monthly dissolved beta activity averages exceeded 200 pc/liter only on the Columbia River. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 91 and 891 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*11*). The Public Health Service Drinking Water Standards state that in the absence of strontium–90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*12*).

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(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

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(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

(*7*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

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(*10*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957-1962, *Radiological Health Data*, *4*:306-16, (June 1963).

(*11*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association*, *53*:704 (June 1961).

(*12*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington D.C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

Section IV—Other Data

STRONTIUM-90 CONTENT OF HUMAN BONES (1961-1963)

Edward S. Weiss, William H. Land, Kenneth H. Falter, and Robert M. Hallisey[1]

Introduction

Even before its production in large quantities, strontium-90 was recognized as a potentially hazardous radionuclide because of its biochemical characteristics and physical behavior. With the advent of high yield weapons testing, Project Sunshine was established to examine more intensively the hazards to man of radioactive debris. The project report (*1*) confirmed an earlier conclusion that strontium-90 was the nuclide of major interest because:

(a) strontium-90, introduced into soil and plants from nuclear weapons tests, finds its way through the food chain to human beings;

(b) when ingested by people, strontium-90 seeks the skeleton and there remains for a period of years; and

(c) infants and children, because of their rapid growth, constitute the critical segment of the population with respect to uptake and retention of this nuclide.

The Project Sunshine report recommended adoption of a sampling program for collection and radiochemical analysis of human bone. Kulp and his associates at the Lamont Geological Observatory actively pursued this proposal, and they first detected environmental strontium-90 in animal bones and in milk products in July 1953.

In 1957, this group reported an average concentration of 0.1 pc strontium-90 per gram of calcium in human beings of all ages for the year 1955 (*2*). The work at Lamont on the geochemistry and biochemistry of strontium-90 still continues although the human bone phase was terminated in 1961, marked by the publication of the three volumes of "Strontium-90 in Man and His Environment" (*3*).

In March 1961, the Health and Safety Laboratory of the Atomic Energy Commission began collecting human bones in the three cities (New York, Chicago and San Francisco) where diet surveillance had been started in 1960 (*4,5*).

In order to permit more intensive study of variations of the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting specimens in late 1961. This report describes and presents the Public Health Service experience and laboratory results for persons who died between November 1961 and August 1963.

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Collection

Pathologists, medical examiners and coroners in large cities were invited to submit human bone specimens by mail. The samples have been obtained in the main from deceased persons, with a small number from living persons as a result of amputations or other surgical procedures. In areas with high population density or elevated environmental strontium–90 levels, efforts to increase participation have been intensified. As a result, about 30 participants in the PHS program have each submitted at least 10 specimens meeting the requirements with respect to age, quantity and cause of death, and another 150 have each provided one or two acceptable specimens.

The target population consists of children and young adults up to 25 years of age. Since strontium–90 in measureable amounts has been present in the global environment for only about 10 years and major calcium accretion ends by age 17 or 18, persons over 25 years of age are of limited interest for this program.

The specimens desired are from persons who were victims of accidents or of an acute disease process that was not likely to impair bone metabolism. The minimum quantity required for an individual laboratory analysis is about 100 grams of wet bone, which is easily obtained from older children but presents some difficulties in infants and children under five years of age.

The most readily obtainable specimens are vertebrae and ribs. Rivera at HASL has restricted his published results to vertebrae and focuses his collection efforts on this type of bone (4,5). It has been found unfeasible to collect long bones in sufficient numbers for direct comparison of results although British investigators have been successful in procuring long bones in quantity. Ribs and vertebrae, being less dense and presumably in a more dynamic state with respect to calcium exchange rate, yield results that may have to be adjusted to provide estimates of the skeletal burden of radiostrontium in older children and in adults.

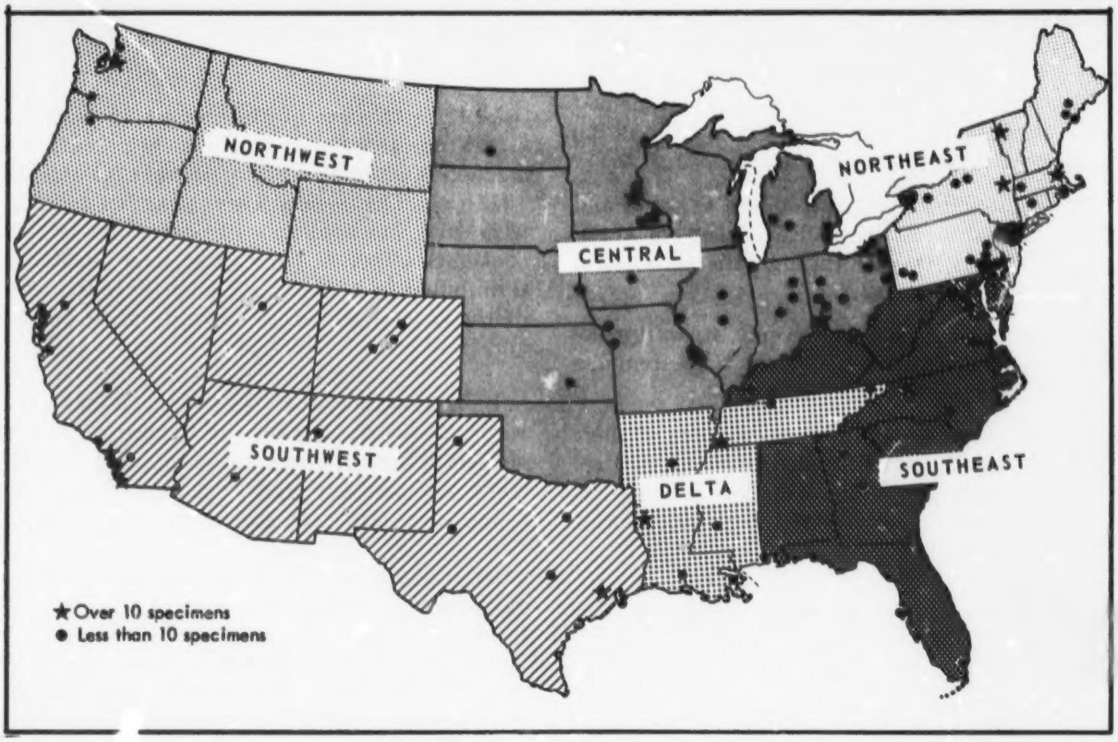

FIGURE 1.—REGIONS FOR PHS BONE SAMPLING PROGRAM AND LOCATION OF COLLECTION CENTERS

For the purposes of this study, the country has been divided into six geographical regions as shown in figure 1. These regions represent an attempt to combine some elements of climatic and topographic homogeneity with the patterns of strontium–90 in the local diet as reflected by the 63 stations in the Public Health Service Pasteurized Milk Network. The locations of bone collection stations are indicated by the symbols superimposed on the figure.

The general characteristics of the 903 specimens collected in the first two years' operations are presented in table 1. Over 600 specimens are suitable for individual analysis and of these, over 400 are in the preferred age group. The specimens weighing less than 100 grams may be pooled in appropriate age groups by region to secure intrinsically useful information or they may be randomly pooled in large quantities for quality control standards. The major deficiencies are in the Mississippi delta region, where the highest strontium–90 concentrations in milk have been observed from time to time, and in the Northwest, where high milk levels followed the last series of weapons tests by the U. S. and the U.S.S.R.

TABLE 1.—SUMMARY OF BONE SPECIMENS RECEIVED

Region	Age of patient at time of death					
	Up to 25 years			25 years and older		
	Less than 100 g.	100 g. or more	Total	Less than 100 g.	100 g. or more	Total
Northeast	44	100	144(24%)	6	86	92(31%)
Southeast	14	44	58(9%)	8	59	67(23%)
Central	77	198	275(45%)	47	38	85(29%)
Delta	10	20	30(5%)	1	8	9(3%)
Northwest	15	20	35(6%)	0	11	11(4%)
Southwest	35	32	67(11%)	8	22	30(10%)
Totals (903)	195	414	609	70	224	294

To supplement the limited information obtained with the specimens, copies of birth and death certificates of each individual will be obtained. This will permit grouping the laboratory results by cause of death, duration of residence in a region, and by socio-economic class as indicated by the father's occupation.

Laboratory Procedures

The bones are ashed in two stages at 800°C in aluminum oxide crucibles at the Northeastern Radiological Health Laboratory at the Division of Radiological Health, at Winchester, Massachusetts. The procedure (*6*) for extracting the strontium–90 and measuring its yttrium–90 daughter involves the following steps:

1. The ash is dissolved in $6N$ hydrochloric acid and made up to 500 ml volume.
2. Approximately 40 mg of yttrium carrier are added to a 200-ml aliquot, the pH is adjusted to 1.0 with ammonium hydroxide and approximately 80 ml of $1N$ oxalic acid is added to precipitate the calcium-strontium-yttrium fraction as the oxalate.
3. The solution is filtered through Whatman #42 filter paper using suction and the precipitate on the filter paper is transferred to a platinum crucible and ignited (Meker burner for 1 hour). The oxalate precipitate is thus converted to the hydroxide-carbonate form.
4. The hydroxide-carbonate precipitate is redissolved in $3N$ nitric acid, adjusted to a pH of 1 with ammonium hydroxide and approximately 80 ml of oxalic acid solution is again added to precipitate yttrium as the oxalate. Step three is repeated.
5. The hydroxide-carbonate precipitate is then dissolve in $3N$ nitric acid and boiled to remove CO_2.
6. The yttrium is precipitated as the hydroxide with ammonium hydroxide and purified by a series of solution-precipitation steps with hydrochloric acid and ammonium hydroxide. This is done until no more calcium carbonate precipitate is observed when sodium carbonate is added to the supernatant liquid portion from the hydroxide precipitation. This requires three to five precipitation steps.
7. The precipitate is dissolved in concentrated hydrochloric acid and the pH is brought to 5 with an acetate buffer solution. Approximately 10 to 20 ml of $0.5M$ 2–thenoyltrifluoroacetone (TTA) in benzene is added. The mixture is extracted for 5 minutes, the layers are allowed to separate, the aqueous phase is drawn off into another separatory funnel, and another 10–20 ml of TTA solution is added. The mixture is ex-

tracted and the layers are allowed to separate. The two TTA solutions are combined and the aqueous phase is discarded.

8. The TTA-benzene is stripped with $0.1N$ nitric acid (pH 1). Approximately 10 ml of $1M$ oxalic acid is added to precipitate the yttrium as the oxalate. The precipitate is collected on glass fiber filter paper, dried, and weighed for chemical yield. The samples were originally counted for 30 minutes with a low background beta counter with automatic sample changer. Starting in September 1963 the counting time was increased to 100 minutes and the samples were counted without the automatic sample changer for 10 minutes.
9. Calculations:

$$S=\frac{(G-B)V}{2.22EADC}, \text{ where} \qquad \text{(Eq. 1)}$$

S = activity of Sr^{90} in sample, pc
G = gross (sample + background) counting rate, cpm
B = background counting rate, cpm
V = volume to which ash solution is diluted (usually 500 ml)
E = counting efficiency, count/disintegration
A = volume taken for aliquot (usually 200 ml)
D = decay factor for Y^{90} from separation (step 2) to counting
C = chemical yield
2.22 = conversion factor, dpm per picocurie, and

$$CE=\frac{1.96\left(\frac{G}{t_g}+\frac{B}{t_b}\right)^{1/2}V}{2.22EADC}, \text{ where} \qquad \text{(Eq. 2)}$$

CE = counting error at 95 percent confidence level, pc
t_g = counting time over which gross counting rate is determined, minutes
t_b = counting time over which background is determined, minutes; the other symbols have the same meanings as above

Results

The results of the 199 individual laboratory analyses on 194 bone specimens (four duplicate analyses) analyzed through October 1963 are summarized in table 2 and given in detail in table 3. In age groups above 0–4 years, the 1963 average values are slightly higher than the 1.0 to 3.2 pc per gram of calcium observed in the previous year. Conversely, the average for the lowest age group has dropped from 4.2 to 3.2 pc per gram in the same period.

The highest bone concentration, 9.7 pc per gram of calcium, was reported for a 1½ year old child in the northeastern region of the U. S.

TABLE 2.—ANALYSES OF STRONTIUM-90 IN BONE, BY AGE AND REGION

[pc Sr^{90}/g calcium]

Region	0–4 yrs.				5–9 yrs.				10–14 yrs.				15–19 yrs.				20–24 yrs.				25+ yrs.				Total No.
	Mean	Min	Max	No.	Mean	Min	Max	No.	Mean	Min	Max	No.	Mean	Min	Max	No.	Mean	Min	Max	No.	Mean	Min	Max	No.	
1961–1962 Deaths																									
Northeast	4.8	1.6	9.7	9	5.1	2.4	9.4	7	2.4	1.4	3.2	7	2.8	1.1	4.6	7	2.1	1.3	4.9	12	1.1	0.9	1.6	3	45
Southeast	5.8	5.2	6.3	2	3.4	3.4	3.4	1	2.5	2.0	3.0	2	2.5	1.9	3.0	4	1.8	1.4	2.2	7	[a]—	—	—	—	16
Central	2.8	1.7	3.9	7	2.2	1.4	2.7	6	2.2	1.2	3.5	8	2.0	1.2	3.4	7	1.6	0.9	2.6	8	0.8	0.8	0.8	1	37
Delta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	1.8	1.6	2.0	2	—	—	—	—	2
Northwest	2.9	2.9	2.9	1	—	—	—	—	2.1	1.8	2.6	3	1.8	1.3	2.4	4	1.7	1.4	2.4	3	—	—	—	—	11
Southwest	4.9	3.0	6.8	2	1.7	1.7	1.7	1	—	—	—	—	3.0	3.0	3.0	1	0.9	0.9	0.9	1	—	—	—	—	5
All	4.2	1.6	9.7	21	3.6	1.4	9.4	15	2.3	1.2	3.5	20	2.3	1.1	4.6	23	1.8	0.9	4.9	33	1.0	0.8	1.6	4	116
1963 Deaths																									
Northeast	3.6	1.2	5.7	4	4.2	3.4	5.5	5	3.6	2.3	5.7	4	3.0	1.6	4.8	19	2.2	1.6	3.1	12	2.4	1.7	3.0	2	46
Southeast	1.9	1.9	1.9	1	—	—	—	—	2.0	2.0	2.0	1	3.9	3.9	3.9	1	1.9	1.5	2.4	4	1.8	1.8	1.8	1	8
Central	3.0	2.4	4.2	8	4.2	4.2	4.2	1	2.3	1.7	3.6	10	2.2	1.4	2.7	3	5.0	5.0	5.0	1	—	—	—	—	23
Delta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Northwest	4.1	3.5	4.7	2	2.4	2.2	2.6	2	3.8	1.8	5.9	2	—	—	—	—	—	—	—	—	—	—	—	—	6
Southwest	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
All	3.2	1.2	5.7	15	3.8	2.2	5.5	8	2.8	1.7	5.9	17	2.9	1.4	4.8	23	2.3	1.5	5.0	17	2.2	1.7	3.0	3	83

[a] Dash indicates no sample received.

TABLE 3.—DETAILS OF INDIVIDUAL BONE SAMPLES AND RESULTS OF STRONTIUM-90 ANALYSES

State and sample no.	Type of bone [a]	Date of death	Age	Sex	Original weight (g)	Ash weight (g)	pc Sr^{90}/g of		
							Ash ($\pm 2\sigma$CE) [b]	Ca	Bone
Calif.									
IX-8 (0003)	V	10/15/62	20y9m3d	F	273.2	40.8	0.34 ±0.07	0.88	0.05
IX-8 (0004)	V	11/6/62	8y4m4d	F	138.1	14.7	0.65 ±0.06	1.69	0.07
IX-8 (0007)	V	12/4/63	17y1m3d	F	204.2	31.1	1.15 ±0.28	3.01	0.17
D. C.									
III-3 (0001)	I V	11/5/62	10y7m	M	115.1	21.7	0.75 ±0.11	2.05	0.15
III-4 (0004)	V	1/7/63	25y1m	F	103.8	14.9	0.63 ±0.14	1.81	0.10
La.									
VII-6 (0001) [c]	V R	10/15/62	24y	M	223.1	42.0	0.70 ±0.13	2.00	0.15
VII-6 (0001) [c]	V R	10/15/62	24y	M	223.1	42.0	0.55 ±0.12	1.56	0.11
Maine									
I-9 (0001)	V S	6/9/63	19y	M	237.6	11.7	1.53 ±0.29	4.70	0.08
Md.									
III-1 (0008)	V	8/4/62	2y	M	95.0	8.1	2.11 ±0.36	5.25	0.18
III-1 (0026)	V	10/22/62	23y4m	M	110.9	14.3	0.62 ±0.14	1.75	0.09
III-6 (0002)	V S F T	1/6/63	3d	M	97.5	17.0	0.77 ±0.14	1.93	0.13
III-7 (0001)	V	11/16/62	19y	M	149.2	20.3	1.16 ±0.19	3.02	0.16
III-7 (0003)	V	11/16/62	16y	M	120.3	17.4	0.77 ±0.16	2.16	0.12
III-7 (0004)	V	11/15/62	16y	M	157.7	24.4	0.69 ±0.11	1.92	0.11
III-7 (0005)	V	11/26/62	22y	M	132.9	21.4	0.86 ±0.11	2.17	0.13
III-7 (0006)	V	10/8/62	20y	M	141.0	18.7	0.70 ±0.14	2.01	0.10
III-7 (0008)	V	10/28/62	1y6m	M	95.6	9.0	2.02 ±0.43	6.27	0.19
III-7 (0009)	V	10/8/62	16y	M	158.9	22.3	0.97 ±0.14	2.79	0.14
III-7 (0010)	V	10/30/62	11y	M	145.3	15.5	1.06 ±0.23	3.03	0.12
III-7 (0011) [c]	V	11/11/62	21y	M	90.2	13.9	0.51 ±0.15	1.48	0.09
III-7 (0011) [c]	V	11/11/62	21y	M	90.2	13.9	0.48 ±0.12	1.41	0.08
III-7 (0013)	V	12/9/62	22y	M	208.5	15.8	0.84 ±0.18	2.16	0.06
III-7 (0014)	V	1/9/63	13y	M	158.4	15.5	0.74 ±0.16	1.99	0.07
III-7 (0015)	V	2/28/63	22y	M	156.6	23.4	0.58 ±0.11	1.52	0.09
III-7 (0017)	V	3/31/63	22y	M	112.6	14.8	0.70 ±0.17	1.84	0.09
III-7 (0018)	V	3/3/63	21y	M	162.0	20.9	0.91 ±0.10	2.38	0.12
III-7 (0019)	V	3/23/63	20y	F	123.6	23.6	0.71 ±0.08	1.97	0.15
III-7 (0020)	V	2/5/63	16y	M	110.3	12.9	1.29 ±0.21	3.89	0.17
III-7 (0021)	V	2/21/63	Unknown	M	127.3	21.9	0.65 ±0.13	1.83	0.12
III-7 (0023)	V	12/17/62	6y	F	114.5	11.5	1.24 ±0.26	3.38	0.12
Mass.									
I-1 (0002)	V	9/19/62	10y	M	166.2	14.4	0.81 ±0.18	2.11	0.07
I-1 (0003)	V	9/30/62	33y	F	172.7	22.9	0.27 ±0.08	0.86	0.04
I-1 (0004)	V S	12/30/62	1y7m	M	87.5	6.7	3.39 ±0.55	9.68	0.25
I-1 (0006)	V S	3/5/63	20y	M	207.4	36.0	0.98 ±0.10	2.50	0.17
I-1 (0007)	V S	4/22/63	14y	F	143.8	11.9	1.18 ±0.24	3.30	0.10
I-1 (0008)	V S	5/6/63	6y	M	93.5	7.3	1.27 ±0.21	4.06	0.11
I-1 (0009)	V	6/5/63	19y	M	263.8	36.6	1.10 ±0.11	2.94	0.15
I-2 (0001)	V	7/26/62	15y7m	M	159.4	23.0	1.47 ±0.22	3.86	0.21
I-2 (0004)	V R	6/21/63	16y9m	F	100.1	9.2	1.01 ±0.18	2.98	0.09
I-2 (0005)	V	6/19/63	4y	M	97.5	8.4	1.98 ±0.23	5.72	0.17
I-2 (0008)	V	7/2/63	8y	F	158.3	14.9	1.31 ±0.21	3.65	0.12
I-2 (0009)	V	7/2/63	6y	M	151.8	10.8	1.57 ±0.18	4.37	0.11
I-2 (0014)	V	8/1/63	9y	F	222.0	12.6	1.85 ±0.28	5.48	0.11
I-2 (0017)	V	7/30/63	10y	M	109.4	10.3	1.95 ±0.21	5.69	0.21
I-3 (0001)	V R	11/8/62	6y	F	147.3	15.1	3.34 ±0.32	9.4	0.34
I-3 (0002)	V	10/3/62	17y8m	M	146.4	15.3	0.94 ±0.23	2.53	0.10
I-5 (0001)	V R	12/2/62	20y	M	78.6	11.6	0.63 ±0.16	1.7	0.09
I-5 (0002)	V R	12/5/62	20y	F	133.0	24.3	0.76 ±0.13	1.9	0.14
I-7 (0001)	V R	11/18/62	19y	M	132.2	16.9	0.46 ±0.14	1.12	0.06
I-7 (0002)	V R	11/30/62	2y	F	53.9	4.5	2.98 ±0.58	8.3	0.25
I-7 (0003)	V R	2/22/63	14y	M	114.2	21.1	1.23 ±0.20	3.10	0.23
I-7 (0004)	V	3/9/63	18y	M	220.7	29.4	0.91 ±0.13	2.37	0.12
Mich.									
V-5 (0002)	V	1/17/63	2y2m16d	F	102.9	9.1	1.31 ±0.14	3.60	0.12
V-5 (0003)	V	2/11/63	22y6m12d	M	245.0	34.2	1.89 ±0.05	4.98	0.26
V-5 (0004)	V	4/18/63	10y3m7d	M	197.5	21.7	1.08 ±0.16	2.83	0.12
V-13 (0001)	V	10/19/62	22y11m12d	M	221.5	26.8	0.42 ±0.10	1.13	0.05
V-13 (0003)	V	10/24/62	19y5m13d	F	156.0	17.8	0.81 ±0.16	2.16	0.09
V-13 (0004)	V	11/6/62	24y11m16d	F	230.5	26.6	0.95 ±0.17	2.45	0.07
V-13 (0006)	V	11/22/62	19y 20d	M	142.6	16.8	1.28 ±0.15	3.37	0.24
V-13 (0007)	V	11/22/62	24y10m25d	M	130.4	17.4	0.57 ±0.15	1.49	0.08
V-13 (0008)	V	12/1/62	15y8m23d	F	152.5	21.7	0.46 ±0.12	1.17	0.07
V-13 (0009)	V	12/14/62	21y7m	M	139.2	22.4	1.01 ±0.16	2.59	0.16
V-13 (0010)	V	12/14/62	19y10m13d	M	116.9	15.9	0.61 ±0.16	1.55	0.08
Minn.									
VI-1 (0001)	V R S	10/20/62	9y2m	F	177.9	17.6	0.99 ±0.20	2.71	0.10
VI-1 (0005)	V S	1/16/63	10y5m27d	F	181.8	20.5	1.30 ±0.17	3.59	0.15
VI-6 (0003) [c]	V S	11/14/62	21y9m11d	M	251.8	32.7	0.33 ±0.09	0.87	0.04
VI-6 (0003) [c]	V S	11/14/62	21y9m11d	M	251.8	32.7	0.38 ±0.08	1.00	0.05
Mo.									
VI-2 (0002)	R	8/4/62	36y5m	M	50.6	16.0	0.30 ±0.12	0.79	0.10

[a] Type of bone: I, ilium; F, femur; Fi, fibula; R, rib; S, sternum; Sk, skull; V, vertebra.
[b] Two standard deviation counting error.
[c] Duplicate analysis.

TABLE 3.—DETAILS OF INDIVIDUAL BONE SAMPLES AND RESULTS OF STRONTIUM-90 ANALYSES—Continued

State and sample no.	Types of bone [a]	Date of death	Age	Sex	Original weight (g)	Ash weight (g)	pc Sr^{90}/g of		
							Ash $(\pm 2\sigma CE)$ [b]	Ca	Bone
N. Y.									
II-9 (0002)	V I F T Fi	9/30/62	1d	M	193.8	16.4	0.74 ±0.18	2.04	0.06
II-10 (0001)	V	11/11/62	21y3m	F	149.7	20.4	0.72 ±0.14	1.89	0.10
II-10 (0004)	V	1/1/63	18y3m	M	173.6	23.7	0.68 ±0.11	1.99	0.10
II-10 (0006)	V	1/24/63	25y8m	M	167.8	19.2	1.08 ±0.20	2.98	0.12
II-10 (0007)	V	4/12/63	16y9m	M	188.8	23.9	1.10 ±0.15	3.00	0.14
II-12 (0001)	V	7/31/62	20y	M	158.2	19.4	0.64 ±0.13	1.70	0.08
II-12 (0003)	V	10/11/62	16y7m	M	174.0	23.1	1.17 ±0.82	3.09	0.15
II-12 (0004)	V	10/6/62	20y1m	M	165.0	21.7	1.17 ±0.21	2.13	0.15
II-12 (0005)	V	12/30/62	10y11m5d	M	157.4	13.7	0.88 ±0.20	2.55	0.08
II-12 (0006)	V	2/4/63	21y11m	M	176.9	20.2	0.73 ±0.14	2.01	0.08
II-12 (0007)	V	2/23/63	19y6m	F	154.9	17.3	1.65 ±0.29	4.43	0.18
II-12 (0008)	V	3/5/63	19y4m	M	156.8	15.4	1.24 ±0.20	3.49	0.12
II-12 (0009)	V	3/20/63	18y11m7d	M	140.5	17.4	0.82 ±0.16	2.17	0.10
Ohio									
V-1 (0001)	V	8/4/62	6y6d	M	164.5	17.6	0.93 ±0.17	2.74	0.10
V-1 (0002)	V	8/10/62	18y7m10d	M	171.5	25.9	0.86 ±0.04	2.14	0.13
V-1 (0003)	V	9/3/62	23y3m	M	151.6	17.4	0.61 ±0.52	1.67	0.07
V-1 (0004)	V	10/15/62	17y2m2d	M	203.7	24.2	0.75 ±0.13	2.02	0.09
V-1 (0005)	V	1/16/63	14y1m27d	M	273.1	30.8	1.04 ±0.04	2.72	0.12
V-1 (0006)	V	1/31/63	14y3m6d	F	333.2	40.5	1.01 ±0.04	2.61	0.12
V-7 (0001)	V	10/19/62	11y4m29d	M	149.0	14.4	1.11 ±0.20	3.15	0.11
V-7 (0002)	V	10/9/62	21y7d	M	160.7	22.4	0.64 ±0.12	1.76	0.09
V-16 (0002)	V	1/16/63	19y6m29d	M	111.0	18.5	1.02 ±0.05	2.57	0.17
V-16 (0003)	V	1/15/63	10y11m15d	F	70.1	8.7	0.53 ±0.14	1.71	0.07
V-16 (0005)	V	2/17/63	19y2m10d	M	107.6	17.2	0.50 ±0.14	1.38	0.08
V-17 (0001)	V	12/10/62	12y1m4d	M	95.0	14.1	1.33 ±0.23	3.47	0.20
V-17 (0003)	V	1/8/63	12y4m9d	M	168.5	17.8	0.57 ±0.14	1.85	0.07
V-17 (0004) [c]	V	2/10/63	11y7m14d	F	219.3	23.8	0.52 ±0.12	1.67	0.07
V-17 (0004) [c]	V	2/10/63	11y7m14d	F	219.3	23.8	0.56 ±0.11	1.77	0.07
V-17 (0005)	V	3/22/63	16y	M	268.7	26.0	0.95 ±0.14	2.66	0.10
V-19 (0001)	V R Sk	11/20/61	3m	M	107.1	9.8	1.02 ±0.10	2.96	0.10
V-19 (0002)	V R S	11/25/61	3m	M	110.5	10.8	0.61 ±0.16	1.75	0.06
V-19 (0004)	V	12/9/61	14y	M	249.1	28.6	1.09 ±0.05	2.79	0.14
V-19 (0005)	V R	12/8/61	1y	M	141.3	11.9	1.16 ±0.19	3.37	0.10
V-19 (0006)	V	12/8/61	12y	F	269.3	33.7	0.60 ±0.08	1.60	0.08
V-19 (0008)	V R	12/23/61	10y	M	200.7	19.1	0.41 ±0.10	1.20	0.04
V-19 (0010)	V R	12/28/61	5y	M	263.8	20.8	0.91 ±0.14	2.74	0.08
V-19 (0011)	V R	12/26/61	10y	F	215.1	20.3	0.57 ±0.10	1.71	0.06
V-19 (0013)	V R	1/4/62	13y	F	276.8	33.2	0.17 ±0.02	2.45	0.02
V-19 (0014)	V R	1/5/62	2y	M	161.3	12.5	0.73 ±0.15	2.10	0.06
V-19 (0015)	V R	1/15/62	4y	M	226.7	20.5	1.26 ±0.17	3.81	0.12
V-19 (0035)	V R Sk	4/11/62	1d	M	90.4	14.8	0.62 ±0.05	1.75	0.12
V-19 (0036)	V	5/23/62	15y1m	M	203.8	24.2	0.56 ±0.09	1.70	0.07
V-19 (0039)	V	5/31/62	7y6d	M	203.1	15.6	0.71 ±0.05	2.28	0.06
V-19 (0044)	V	7/14/62	14y6m	F	297.9	36.7	0.53 ±0.07	1.53	0.07
Pa.									
II-1 (0001)	V I	7/13/62	5y1m	F	153.5	15.6	2.28 ±0.32	6.01	0.23
II-1 (0003)	V R	7/27/62	2y10m	M	85.4	8.7	1.87 ±0.36	5.20	0.19
II-1 (0004)	V	9/1/62	3y	F	107.6	8.9	1.37 ±0.26	3.86	0.11
II-1 (0005)	V	11/16/62	8y11m	F	122.5	11.4	1.59 ±0.50	4.50	0.15
II-2 (0001) [c]	V	7/26/62	14y11m	M	327.3	23.6	0.90 ±0.13	2.30	0.07
II-2 (0001) [c]	V	7/26/62	14y11m	M	327.3	28.3	0.53 ±0.09	1.38	0.05
II-2 (0002)	V	8/2/62	13y11m	M	179.1	19.0	1.08 ±0.76	2.93	0.12
II-2 (0003)	V	8/11/62	6y6m	F	196.2	18.9	1.47 ±0.24	4.00	0.14
II-2 (0004)	V	8/27/62	6y3m20d	F	99.7	8.1	0.77 ±0.10	2.40	0.07
II-2 (0005)	V	10/2/62	9y8m6d	F	146.3	13.6	2.39 ±0.13	7.07	0.24
II-3 (0002)	V	2/1/63	20y4m25d	M	100.7	10.0	1.13 ±0.08	3.14	0.12
II-4 (0001)	V	7/18/62	25y11m	M	220.0	30.7	0.40 ±1.01	1.01	0.06
II-4 (0005)	V	8/12/62	18y3m	M	148.5	19.2	0.77 ±0.16	2.00	0.10
II-4 (0006)	V	8/23/62	9y10m	M	134.1	12.6	0.92 ±0.22	2.57	0.09
II-4 (0007)	V	10/14/62	1y4m29d	M	72.3	7.1	2.02 ±0.18	5.55	0.20
II-4 (0010)	V	11/30/62	22y1m8d	M	89.5	11.5	1.73 ±0.09	4.88	0.24
II-4 (0014)	V	1/23/63	19y4m17d	M	153.6	21.2	1.09 ±0.05	2.98	0.16
II-5 (0003)	V R F	7/29/62	2d	F	67.3	9.8	0.61 ±0.19	1.55	0.09
II-6 (0038)	V	1/9/63	17y3d	F	121.6	14.9	0.56 ±0.05	1.59	0.07
II-6 (0042)	V	2/12/63	17y10m17d	M	148.3	18.1	1.04 ±0.05	2.80	0.13
II-6 (0047)	V	2/25/63	4m8d	F	111.2	14.9	0.42 ±0.05	1.15	0.06
II-19 (0002)	V	10/18/62	10y2m	M	211.6	21.3	0.99 ±0.13	2.61	0.10
II-19 (0003)	V	10/13/62	25y3m	M	207.6	31.7	0.60 ±0.09	1.55	0.09
II-19 (0004)	V	11/1/62	23y1m	M	161.0	26.4	0.64 ±0.13	1.66	0.10
II-19 (0006)	V	11/2/62	14y9m	M	259.5	34.5	1.20 ±0.15	3.16	0.16
II-19 (0007)	V R	11/1/62	1d	F	199.9	17.1	1.47 ±0.23	4.05	0.13
II-19 (0009)	V	11/6/62	16y8m	M	146.5	13.3	1.68 ±0.26	4.64	0.15
II-19 (0010)	V R	11/6/62	4y11m	M	160.4	21.7	1.23 ±0.20	3.38	0.17

[a] Types of bone: I, ilium F, femur; Fi, fibula; R, rib; S, sternum; Sk, skull; V, vertebra.
[b] Two standard deviation counting error.
[c] Duplicate analysis.

TABLE 3.—DETAILS OF INDIVIDUAL BONE SAMPLES AND RESULTS OF STRONTIUM-90 ANALYSES—Continued

State and sample no.	Types of bone [a]	Date of death	Age	Sex	Original weight (g)	Ash weight (g)	pc Sr^{90}/g of		
							Ash ($+2\sigma$CE) [b]	Ca	Bone
Pa.—Continued									
II-19 (0011)	V	11/16/62	20y2m	M	166.8	28.2	0.91±0.14	2.50	0.16
II-19 (0012)	V	12/6/62	17y	M	179.8	25.1	0.72±0.12	2.07	0.11
II-19 (0013)	V	12/26/62	21y	M	166.3	20.8	0.82±0.13	2.35	0.11
II-19 (0014)	V	12/18/62	23y	M	209.0	33.5	0.45±0.07	1.32	0.08
II-19 (0015)	V	1/7/63	25y	M	145.7	22.9	0.63±0.00	1.74	0.11
II-19 (0016)	V	1/10/63	17y26d	M	208.7	34.6	1.05±0.04	2.89	0.18
II-19 (0018)	V R	1/19/63	1y11m	F	197.3	12.7	1.45±0.24	4.21	0.09
II-19 (0021)	V	2/18/63	22y	M	188.3	28.4	0.61±0.13	1.69	0.10
II-19 (0022)	V	2/23/62	16y11m	F	166.2	22.7	0.59±0.12	1.67	0.09
II-19 (0023)	V R	2/24/63	4y5m16d	F	123.7	9.5	1.22±0.12	3.34	0.09
II-19 (0025)	V	3/8/63	20y7m	M	156.5	24.1	0.82±0.04	2.38	0.14
II-19 (0028)	V	4/10/63	24y1m3d	F	173.4	25.7	0.83±0.04	2.28	0.13
II-19 (0029)	V	4/22/63	10y5m	M	92.6	11.6	0.76±0.22	2.31	0.10
II-19 (0036)	V	4/15/63	9y10m	M	145.7	16.4	1.15±0.15	3.45	0.14
II-19 (0031)	V	4/14/63	22y4m	M	144.1	20.5	0.74±0.12	2.10	0.14
Texas									
VII-1 (0001)	V R	7/15/62	4y10m13d	F	93.0	13.5	1.01±0.23	2.98	0.15
VII-1 (0002)	V R	7/17/62	1y3m16d	M	108.3	11.3	2.37±0.35	6.82	0.26
Vt.									
I-6 (0001)	V	10/28/62	22y	M	148.6	27.1	0.62±0.06	1.6	0.11
I-6 (0003)	V	11/25/62	22y	M	275.8	36.55	0.62±0.11	1.6	0.08
I-6 (0005)	V	12/20/62	17y	M	206.3	31.4	1.11±0.12	2.96	0.17
I-6 (0007)	V	1/18/63	17y	M	175.6	28.9	1.20±0.13	3.17	0.20
I-6 (0008)	V	2/5/63	22y	F	170.8	25.0	0.87±0.13	2.30	0.13
I-6 (0009)	V	4/4/63	22y	F	182.8	25.4	0.52±0.11	1.60	0.08
I-6 (0012)	V	4/17/63	18y	M	281.2	36.1	0.94±0.11	2.50	0.12
I-6 (0014)	V	4/29/63	18y	M	182.4	24.2	1.81±0.18	4.78	0.24
I-6 (0017)	V	6/1/63	21y	F	229.9	35.3	0.81±0.10	2.13	0.13
I-6 (0022)	V	6/18/63	23y	F	182.0	26.9	0.63±0.31	1.78	0.10
I-6 (0024)	V	8/23/63	23y	M	206.6	31.2	0.83±0.11	2.17	0.13
I-6 (0026)	V	7/5/63	15y	M	178.8	20.4	1.32±0.17	3.48	0.15
Va.									
III-5 (0001)	R V	12/18/62	20y	M	178.8	29.5	0.78±0.11	1.99	0.13
Wash.									
IX-3 (0004)	V	8/24/62	15y8m	F	87.1	16.5	0.95±0.17	2.41	0.18
IX-3 (0005)	V	8/31/62	12y6m	M	86.8	15.1	1.04±0.17	2.63	0.18
IX-3 (0006)	V	9/3/62	19y10m10d	M	178.7	23.3	0.52±0.14	1.32	0.07
IX-3 (0007)	V	9/17/62	14y6m	M	102.3	15.8	0.72±0.16	1.84	0.11
IX-3 (0008)	V	9/15/62	24y	F	113.8	23.2	0.50±0.09	1.36	0.11
IX-7 (0002)	V	10/1/62	16y6m2d	F	86.4	9.0	0.72±0.10	1.90	0.08
IX-7 (0007)	V	11/28/62	10y3m	M	164.7	12.8	0.71±0.16	1.96	0.06
IX-7 (0008)	V	12/7/62	4y11m	M	110.3	8.4	1.04±0.23	2.94	0.08
IX-7 (0009)	R V	12/12/62	13y11m	F	169.1	21.5	0.87±0.14	2.36	0.11
IX-7 (0010)	V	1/8/63	3y5m	M	119.8	11.4	1.67±0.26	4.72	0.16
IX-7 (0011)	V	1/15/63	2y4m	F	88.8	7.9	1.22±0.03	3.46	0.11
IX-7 (0012)	V	1/16/63	8y4m	M	174.1	16.5	0.94±0.18	2.59	0.09
IX-7 (0013)	V	1/22/63	7y4m	M	114.1	10.0	0.81±0.20	2.22	0.07
IX-7 (0014)	V	1/24/63	10y10m	M	128.7	13.0	0.61±0.15	1.84	0.06
IX-7 (0017)	V	3/9/63	14y1m10d	F	228.9	26.1	1.91±0.06	5.86	0.21
IX-10 (0001)	R I	11/13/62	22y5m	M	128.8	29.3	0.61±0.09	1.51	0.14
IX-10 (0002)	R	12/3/62	19y1m	M	89.5	22.1	0.59±0.12	1.46	0.15
Wisc.									
V-3 (0007)	V	12/10/62	2y3m9d	M	113.1	11.9	1.39±0.27	3.90	0.15
V-3 (0009)	V	1/8/63	3y1m20d	M	196.3	18.3	0.88±0.16	2.45	0.08
V-3 (0010)	V	1/8/63	3y5m18d	M	138.3	12.8	1.02±0.23	2.58	0.09
V-3 (0012)	V	1/20/63	3y10m25d	F	162.8	16.1	1.09±0.06	2.97	0.11
V-3 (0016)	V	2/21/63	2y5m2d	F	95.2	7.6	0.92±0.20	2.68	0.07
V-3 (0017)	V	2/25/63	5y2m5d	M	181.1	15.8	1.57±0.22	4.23	0.14
V-3 (0018)	V	3/4/63	1y7m23d	F	112.4	10.9	1.58±0.19	4.23	0.15
V-3 (0019)	V	3/1/63	10y1m	M	252.5	21.5	1.02±0.15	2.85	0.09
V-3 (0023)	V	3/5/63	2y5m8d	F	121.1	11.9	0.98±0.14	2.69	0.10
V-3 (0025)	V	3/21/63	4y9m1d	F	160.4	16.4	1.00±0.19	2.71	0.10
V-3 (0029)	V	3/31/63	10y6m2d	M	256.8	26.4	0.49±0.10	1.76	0.06
V-4 (0001)	V	10/6/62	8y8m21d	F	91.9	8.0	0.55±0.17	1.58	0.05
V-4 (0002)	V	10/23/62	8y10m5d	F	67.7	8.4	0.52±0.16	1.39	0.06

[a] Type of bone: I, ilium; F, femur; Fi, fibula; R, rib; S, sternum; Sk, skull; V, vertebra.
[b] Two standard deviation counting error.
[c] Duplicate analysis.

Discussion

The Federal Radiation Council (FRC) states (7) that "As a step in the development of guidance on *intake* of strontium-90, it is necessary to determine the average daily intake of strontium-90 which would correspond to doses of one-third the RPG's to be applied to suitable samples of an exposed population group." In its first report (*8*) the Council cautions that the use of a population average guide "is per-

8b

missible only when there is a probability of appreciable homogeneity concerning the distribution of the dose within the population included in the average."

Since intake is related to dose on the basis of skeletal concentration, the Council states that "a continued dietary ratio of 200 pc of strontium-90 per gram of calcium is estimated to result in a skeletal concentration of 50 pc per gram of calcium and to produce radiation doses, averaged over any age group of a uniformly exposed population group, corresponding to approximately one-third of the appropriate RPG's." (*9*)

In order to provide some estimate of the public health significance of the individual high measurement of 9.7 pc per gram of calcium, it can be compared with some fraction or multiple of 50 pc despite recognition of the fact that the source of the strontium-90 is unquestionably fallout from weapons tests and therefore not a situation covered by the FRC guidance.

For convenience of reference, selected bone concentrations corresponding to "ranges of transient rates of daily intake" are given in table 4.

TABLE 4.—STRONTIUM-90 SKELETAL CONCENTRATIONS CORRESPONDING TO FEDERAL RADIATION COUNCIL RANGES

[pc/g calcium]

FRC Range	Population "Average"	Individuals
I	0–5	0–15
II	5–50	15–150
III	over 50	over 150

The highest single value for an individual, 9.7 pc strontium–90 per gram of calcium, was measured in the 0–4 age group in 1962. This finding corresponds to a daily intake which is less than the upper level of the Federal Radiation Council Range I for a measurement on an individual.

Where comparable with respect to age and year of death, the overall results are slightly above those reported by Rivera (*4,5*) although no single value exceeds 10 pc per gram of calcium.

The very fact of death at a young age implies that the deceased are not randomly drawn from the exposed population. An appropriate sample would require taking into account factors affecting intake such as age, sex, geographical area and economic status, and those affecting calcium and strontium metabolism as reflected by the nature of the cause of death.

Since specimens are almost always collected at autopsy and submitted to the program by voluntary arrangments, it is difficult to satisfy the ideal sampling criteria. Nevertheless, some criterion of adequacy of numbers is called for and it is suggested that 0.1 percent of the annual number of deaths under 1 year of age and 1 percent in each of the other groups through age 24 be used. Using 1960 mortality data (*10*), this would provide about 700 specimens, 100 under 1 year of age and 600 from 1–24 years. These numbers are proposed for the determination of national averages. The same proportions are recommended for each of the regions within the country. On the basis of the experience to date this is a feasible goal.

As the number of samples reported does not yet approach those proposed for a "suitable sample of the exposed population," the mean values shown in table 2 have not been compared with each other or with skeletal concentrations corresponding to FRC ranges for population averages.

Acknowledgments

This program is dependent on the many resources of the Division of Radiological Health, Public Health Service, and the cooperation of the participating pathologists, medical examiners and coroners. We regret that we cannot list them by name nor all of the staff of the Division who have made significant contributions. However, special recognition must be given to Dr. Abraham S. Goldin, Deputy Officer in Charge, Northeastern Radiological Health Laboratory; Edmond Baratta, Chief of Analytical Services, Northeastern Radiological Health Laboratory; and Louise French and Virginia Canavin of the Research Branch.

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ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC installations have appeared periodically in *RHD* since November 1960. Summaries follow for Feed Materials Production Center (FMPC), Fernald, Ohio and Feed Materials Production Facilities (FMPF), Weldon Springs, Missouri.

Releases of radioactive materials from these plants for the periods covered in the reports below are regulated in accordance with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—MAXIMUM PERMISSIBLE CONCENTRATIONS PERTAINING TO ENVIRONMENTAL MONITORING AT FMPC AND FMPF [a]

Radionuclide	Air (pc/m^3)	Water (pc/liter)
Total activity in air if α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present [b]	100	—
Total activity in water if Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present [b]	—	3,000
Uranium-natural	2	20,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to Federal Register, Title 10, Part 20, August 9, 1961, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

1. Feed Materials Production Center, July 1962-December 1963

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC), is operated by the National Lead Company of Ohio (NLO) for the AEC. The location, as related to populated areas, is shown in figure 1.

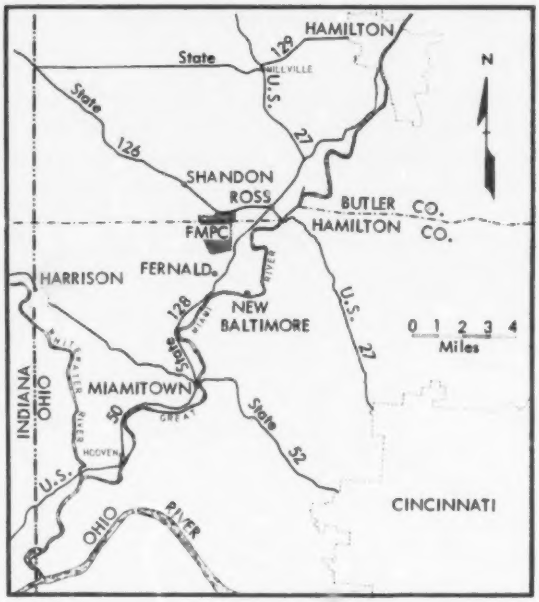

FIGURE 1.—AREA MAP OF FEED MATERIALS PRODUCTION CENTER

Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with the fabrication of the metal into fuel elements.

An environmental survey program of air and water sampling is maintained to check the effectiveness of dust collectors and waste treatment processes.

Air Monitoring

FMPC uses dust collectors, such as bag collectors, electrostatic precipitators and scrubbing towers, which remove nearly all of the airborne particulates generated during the many plant operations. The environmental air sampling program provides an indication of the amount of material released into the atmosphere.

On-site samples were taken at four permanent sampling stations located at the four corners of the production area shown in figure 2. Off-site samples were taken by a mobile unit operated at various distances and directions from the plant determined by local meteorological-conditions on the day of sampling. The data for the off-site samples are averaged in groups according to distance from the production area. Concentrations of uranium and total activity of airborne particulates sampled at on-site and off-site locations are given in table 2.

Water Monitoring

Continuous daily samples, collected from the combined sewer leading from the FMPC site to the Great Miami River are analyzed for uranium and total activity. The combined sewage is composed of treated liquid effluent from the production plants, water treatment plants waste effluent, storm sewer discharge, and treated sanitary sewage. Using the data from the combined sewage samples and stream flow data for the Great Miami River, the FMPC contribution to radioactivity concentrations in the river may be calculated. To check the calculated results, weekly upstream and downstream spot samples are taken. Table 3 presents the calculated and the spot check river concentrations. Since the calculated concentration represents only the contribution from FMPC, it should be compared with the difference of the upstream and downstream measurements. Sampling points are shown in figure 2.

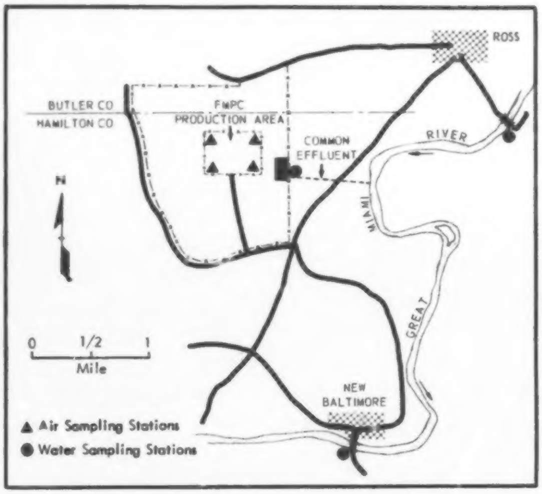

FIGURE 2.—AIR AND WATER SAMPLING STATIONS, FEED MATERIALS PRODUCTION CENTER

Previous coverage in *RHD:*

Period	Issue
January 1959-June 1960	*April 1961*
July-December 1960	*June 1961*
January-June 1961	*December 1961*
July 1961-June 1962	*March 1963*

TABLE 2.—RADIOACTIVITY OF AIRBORNE PARTICULATES, FMPC

[Average concentrations in pc/m³]

Location	Second half 1962			First half 1963			Second half 1963		
	No. of samples	Uranium	Total activity	No. of samples	Uranium	Total activity	No. of samples	Uranium	Total activity
On-site									
Southwest	25	0.16	3.16	25	0.28	6.09	27	0.24	1.86
Northwest	25	0.06	2.39	24	0.11	5.27	27	0.12	1.61
Northeast	23	0.14	2.78	26	0.33	6.00	27	0.25	2.10
Southeast	24	0.13	2.75	25	0.24	5.11	27	0.17	1.64
All on-site samples	97	0.13	2.77	100	0.24	5.62	108	0.20	1.80
Off-site									
0-2 miles from FMPC	6	0.09	5.08	23	0.11	6.25	30	0.34	2.54
2-4 miles from FMPC	6	0.18	3.86	16	0.09	5.10	26	0.08	1.57
4-8 miles from FMPC	3	0.04	0.65	12	0.05	3.59	26	0.06	2.07
8-10 miles from FMPC	2	1.07	5.52	4	0.06	3.80	8	0.05	1.07
All off-site samples	17	0.22	3.67	55	0.09	5.16	90	0.16	1.99

TABLE 3.—CONCENTRATIONS OF URANIUM AND TOTAL ACTIVITY IN THE GREAT MIAMI RIVER, OHIO

[Average concentrations in pc/liter]

Location	Method of determination	Second half 1962			First half 1963			Second half 1963		
		No. of samples	Uranium	Total activity	No. of samples	Uranium	Total activity	No. of samples	Uranium	Total activity
Sewer outfall	Calculated from sewer concentrations and stream data (continuous sampling).	184	126	26	181	5	6	184	12	12
Upstream	Spot samples	32	9	36	28	7	6	26	5	28
Downstream	Spot samples	32	16	50	31	1	8	67	13	48
Difference		—	7	14	3	6	2	41	8	20

2. Feed Materials Production Facilities, July 1962-December 1963

Malinckrodt Chemical Works Weldon Spring, Missouri

Environmental monitoring results at the Feed Materials Production Facilities (FMPC), are reported in uranium concentrations since uranium ore concentrates constitute the primary feed material.

Process chemical wastes and other process residues are permanently retained in storage facilities located at both the plant site and two storage sites located adjacent to the Lambert-St. Louis Municipal Airport and at a quarry near the Missouri River (see figure 3). The plant process sewer, which carries the remaining water effluent from the operations into the Missouri River, is automatically sampled daily to permit continual measurement of any release of uranium-bearing material into the river.

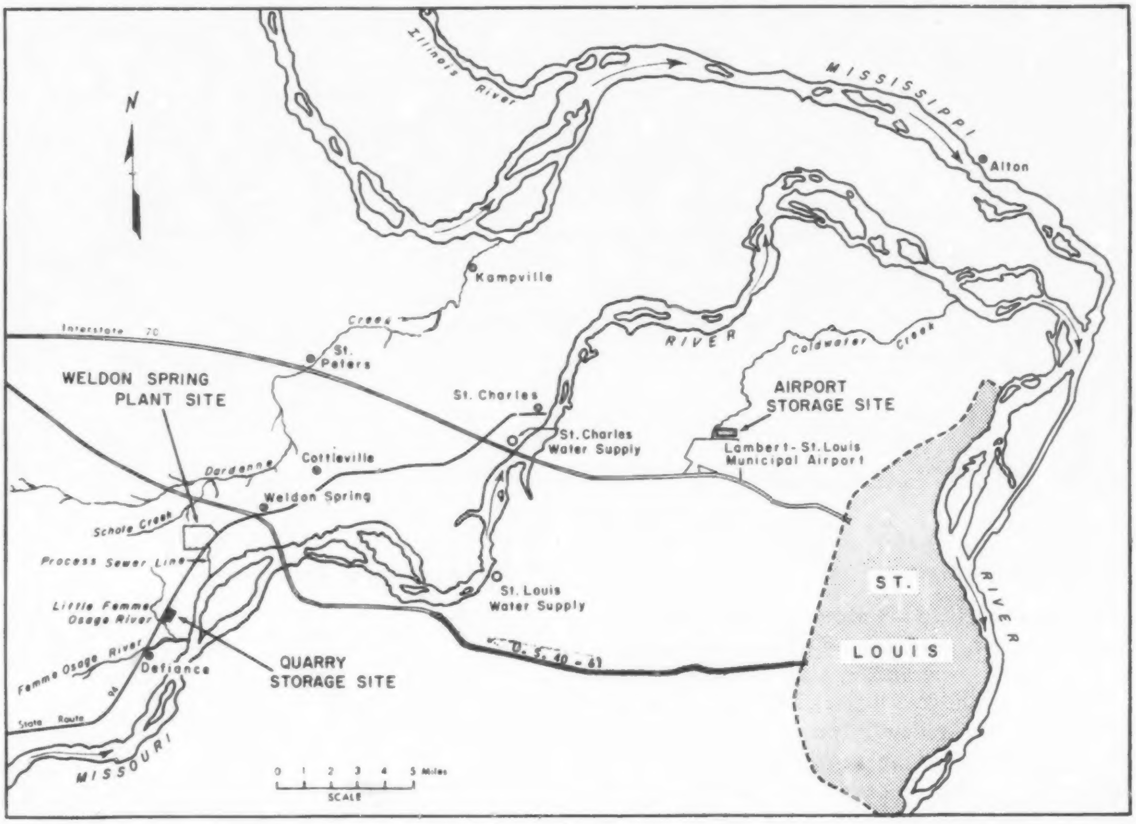
N
Illinois River
MISSISSIPPI
Alton
Kampville
Creek
Interstate 70
St. Peters
RIVER
Coldwater Creek
WELDON SPRING PLANT SITE
St. Charles
AIRPORT STORAGE SITE
St. Charles Water Supply
Lambert - St. Louis Municipal Airport
Cottleville
Dardenne
Weldon Spring
Schote Creek
Process Sewer Line
St. Louis Water Supply
ST.
LOUIS
Little Femme Osage River
Femme Osage River
Defiance
QUARRY STORAGE SITE
U. S. 40 - 61
RIVER
State Route 94
MISSOURI
0 1 2 3 4 5 Miles
SCALE

FIGURE 3.—LOCATION OF FEED MATERIALS PRODUCTION FACILITIES, WELDON SPRING, MO.

Air Monitoring

Monthly air samples are collected along the plant perimeter by 9 high-volume sampling pumps. Midway during the second half of 1962 three of the samplers were moved from their former locations on building roofs to their present perimeter locations. Some of the averages for the second half 1962 given in table 2 therefore are made up of data from two locations but the same general direction from the area of discharge.

Semiannual air samples are collected at 4 points on the perimeter of the airport storage site, and monthly air samples are collected at the south edge of the quarry. Semiannual average uranium concentrations are reported in table 4. Averages ranged from 0.05 percent to 23 percent of the environmental MPC for uranium in air.

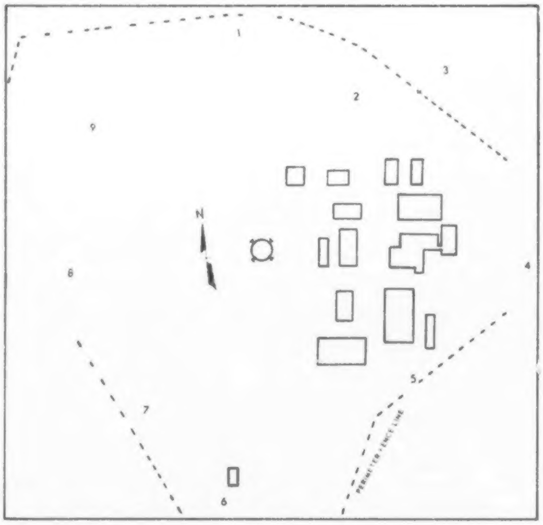

FIGURE 4.—PERIMETER AIR SAMPLING STATIONS, WELDON SPRING PLANT

TABLE 4.—URANIUM CONCENTRATIONS IN AIR—FMPF

[Average concentrations in pc/liter]

Site	Station location (see figure 4)	Second half 1962		First half 1963		Second half 1963	
		Number of samples	Uranium	Number of samples	Uranium	Number of samples	Uranium
Plant	1	3	0.167	5	0.121	6	0.17
	2	3	0.048	6	0.220	6	0.28
	3	3	0.064	6	0.[illegible]22	6	0.054
	4	3	0.062	4	0.085	6	0.085
	5	3	0.038	6	0.258	6	0.46
	6	3	0.106	6	0.057	6	0.017
	7	3	0.057	4	0.178	6	0.065
	8	3	0.123	5	0.074	6	0.16
	9	3	0.116	3	0.053	6	0.21
	Average	—	0.087	—	0.096	—	0.166
Quarry	South edge	6	0.013	6	0.096	6	0.014
Airport	North	1	0.070	1	0.027	1	0.015
	West	1	0.100	1	0.027	1	<0.001
	East	1	0.045	1	0.090	1	0.011
	South	1	0.033	1	0.170	1	0.012

[a] Plant site data given here represent the fourth quarter only because sampling locations were changed at the end of the third quarter. Third quarter plant site station averages ranged from 0.004 pc/m³ to 0.380 pc/m³ with an average value of 0.083 pc/m³.

Water Monitoring

In addition to daily samples from the plant process sewer, monthly off-site water samples are collected from lakes and streams located within the plant's watershed, the Missouri River, and streams near the quarry and airport storage area sites at the points indicated in table 5. Average uranium concentrations ranged from 0.01 percent to 4.4 percent of the environmental MPC.

Previous coverage in *RHD*:

Period	Issue
January 1959-April 1960	*November 1960*
July-December 1960	*November 1961*
January-June 1961	*November 1961*
July-December 1961	*July 1962*
January-June 1962	*November 1962*

TABLE 5.—URANIUM CONCENTRATIONS IN WATER—FMPF

[Average concentrations in pc/liter]

Sampling locations	Second half 1962		First half 1963		Second half 1963	
	Number of samples	Uranium	Number of samples	Uranium	Number of samples	Uranium
Process sewer, plant site	120	480	124	860	120	900
Missouri River sampling points:						
Defiance, upstream	6	4	2	2	2	4
Femme Osage junction, upstream	6	1	2	1	2	1
Process sewer outfall	6	200	6	210	0	—
U. S. Highway 40-61, north side	6	2	0	—	0	—
U. S. Highway 40-61, south side	5	2	2	8	2	10
St. Louis city water plant intake	6	2	2	2	2	12
St. Charles city water plant intake	6	1	2	8	2	5
Plant offsite sampling points:						
Lake, east of plant	6	2	2	4	2	13
Lake, north of plant	6	1	2	1	2	6
Lake, west of plant	6	8	2	2	2	4
Lake, south of plant	6	1	2	10	2	16
Dardenne Creek, upstream	6	1	2	4	2	6
Dardenne Creek, Cottleville Bridge	6	3	2	7	2	4
Dardenne Creek, St. Peters	6	2	2	4	2	6
Dardenne Creek, Kampville	6	2	2	7	2	8
Schote Creek, upstream	6	1	2	2	1	5
Schote Creek, downstream	6	8	6	18	6	29
Plant surface drainage, west	6	130	6	140	6	130
Plant surface drainage, north	6	170	6	160	6	180
Quarry offsite sampling points:						
Little Femme Osage (LFO), ¼ mi. upstream	6	<1	2	<1	2	1
Branch, LFO, ¼ mi. upstream	6	1	2	<1	2	2
LFO, at quarry discharge culvert	6	<1	6	50	6	2
LFO, ¼ mi. downstream	6	<1	2	<1	2	2
LFO, 1¼ mi. downstream	6	<1	2	<1	2	2
Airport offsite sampling points:						
Cold Water Creek, southwest corner of site	1	2	1	<1	1	2
Cold Water Creek, northwest corner of site	1	2	1	<1	1	2
Drainage ditch, north of site	dry	—	1	140	1	90
After site pond discharge	1	100	1	<1	1	1

REPORTED NUCLEAR DETONATIONS, APRIL 1964

Four underground nuclear detonations at the Nevada Test Site during April 1964 were announced by the Atomic Energy Commission. The tests conducted on April 14, 15 and 29 were of low yield, and the test conducted on April 24 was of low intermediate yield. (Low yield range is defined as less than 20 kilotons; low intermediate yield means 20 to 200 kilotons.) Arbitrary reference numbers 152 through 155 were assigned in the order of the test dates by *Radiological Health Data.*

RADIOLOGICAL HEALTH DATA

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service • Division of Radiological Health

Section I—Air and Fallout

FISSION PRODUCT BETA ACTIVITY IN AIRBORNE PARTICULATES AND PRECIPITATION

Continuous surveillance of gross beta activity in air and precipitation provides one of the earliest and most sensitive indications of changes in environmental fission product activity. Although this surveillance does not provide enough information to assess human radiation exposure from fallout, it is widely used as the basis of alerting systems for determining when to intensify monitoring in other phases of the environment.

Surveillance data from a number of national programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. Data provided this month by programs of the Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization are presented individually in tabular form and are also shown by beta concentration isograms in figure 4.

1. Radiation Surveillance Network, February 1964

Division of Radiological Health,
Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Surveillance Network (RSN) of the PHS Division of Radiological Health which gathers samples from 74 stations distributed throughout the country (figure 1). During February, a new station, Montgomery, Alabama, was added to the network. Most of the stations are operated by State health department personnel trained in procedures necessary to obtain the measurements as described and presented below.

The alerting function of the Network is provided by field estimates of the gross beta activity of airborne particulates on the filters. These determinations are performed about 5 hours after the end of the sampling period to eliminate interference from naturally-occurring radon daughters. The Network station operators regularly report their field estimates to the Radiation Surveillance Center, Division of Radiological Health, Washington, D. C. These field estimates are reported monthly (*1*).

Air

Airborne particulates are collected continuously on a carbon-loaded cellulose dust filter 4 inches in diameter. A volume of about 1800 cubic meters of air is drawn through the filter during the 24-hour sampling period by a high volume centrifugal blower.

The filters are forwarded to the Radiation Surveillance Network laboratory in Rockville, Maryland, and the gross beta activity is measured using a thin-window, gas-flow proportional counter, calibrated with a 38,700 pc Sr^{90}–Y^{90} standard.[1] Each filter is counted at least 3 days after the end of the sampling period and again 7 days later. The initial 3-day aging of the sample eliminates interference from naturally-occurring radon and thoron daughters. From the two counts, which are separated by the 7-day interval, it is possible to estimate the age of fission products and to extrapolate the activity to the time of collection. The extrapolation is performed by using the Way-Wigner formula (*2*).[2] The daily concentrations and estimated age are reported by the PHS in a monthly RSN report (*1*). The sample with the highest activity for February was from Las Vegas, Nevada (collected on Febru-

---

[1] The Sr^{90}–Y^{90} source currently used as a standard was used from April 1962 to August 1963 as 40,000 pc total activity. Beginning with September 1963 data the nominal activity of the standard was adjusted for decay (about 2½ percent per year) to 38,700 pc.

[2] $AT^{1.2}=C$, where A is the activity, T is the time (in any time unit) after fission product formation, and C is a constant equal to the activity at $T=1$.

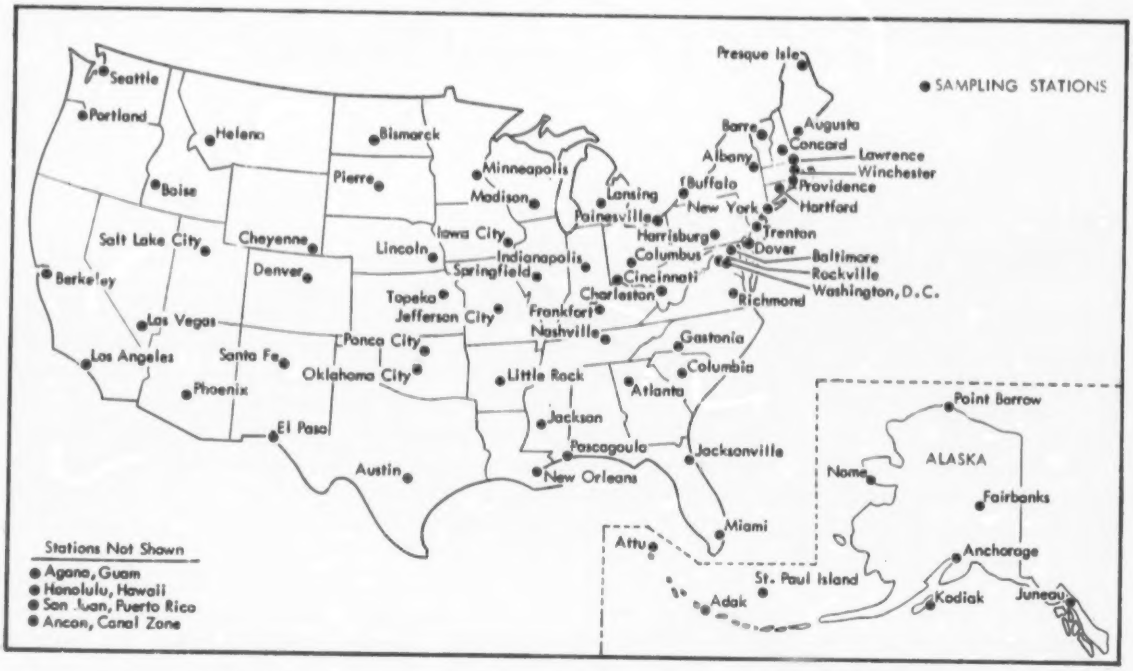
Seattle
Portland
Helena
Bismarck
Presque Isle
SAMPLING STATIONS
Augusta
Barre
Concord
Lawrence
Winchester
Albany
Buffalo
Providence
Hartford
New York
Minneapolis
Pierre
Boise
Madison
Lansing
Painesville
Trenton
Harrisburg
Dover
Baltimore
Rockville
Washington, D.C.
Salt Lake City
Cheyenne
Lincoln
Iowa City
Indianapolis
Columbus
Cincinnati
Springfield
Denver
Berkeley
Topeka
Jefferson City
Frankfort
Charleston
Richmond
Las Vegas
Nashville
Ponca City
Gastonia
Los Angeles
Santa Fe
Oklahoma City
Little Rock
Columbia
Atlanta
Phoenix
Point Barrow
Jackson
El Paso
ALASKA
Nome
Pascagoula
Jacksonville
Austin
New Orleans
Fairbanks
Miami
Stations Not Shown
Agana, Guam
Honolulu, Hawaii
San Juan, Puerto Rico
Ancon, Canal Zone
Attu
Anchorage
St. Paul Island
Adak
Kodiak
Juneau

FIGURE 1.—RADIATION SURVEILLANCE NETWORK SAMPLING STATIONS, FEBRUARY 1964

ary 5), with an activity of 5.2 pc/m^3. Eighteen other samples with activities exceeding 3.5 pc/m^3 were collected: Phoenix, Arizona (2/10, 2/11, 2/12, 2/27); Los Angeles, California (2/3, 2/4, 2/21); Jacksonville, Florida (2/1); Miami, Florida (2/1, 2/18); Sante Fe, New Mexico (2/16, 2/29); Las Vegas, Nevada (2/1, 2/24, 2/26); and El Paso, Texas (2/13, 2/14, 2/16). All of these samples indicated an age of more than 100 days.

The February 1964 fission-product beta concentrations in surface air (extrapolated to the time of collection) are given in table 1. RSN data, along with Canadian and Mexican air data, are represented by isograms in figure 4. The RSN network average for February (1.09) showed a slight increase over the January average (0.94), significant at the 95 percent confidence level. This may be an early influence of the spring rise, which is evidenced by the general latitude[3] and fission product age of 19 samples with highest concentration mentioned above.

Precipitation

Continuous sampling for total precipitation is conducted at most stations on a daily basis, using funnels with collection areas of 0.4 square meter. A 500-ml aliquot of the collected precipitation is evaporated to dryness, and the residue is forwarded to the laboratory for analysis. If the collected sample is between 200 and 500 ml, the entire sample is evaporated. When a sample is smaller than 200 ml (equivalent to 0.5 mm or 0.02 inches of rainfall), the volume of precipitation is reported, but no analysis is made.

In the laboratory the gross beta activity in precipitation is determined by counting the evaporated sample by the same method used for analyzing the air filters, including the extrapolation to time of collection. Deposition for the sample is determined by:

$$D = \frac{CP}{1000}$$

where D is the deposition in nc/m^2, C is the concentration in pc/liter, and P is the depth of precipitation in mm. The individual values of deposition and depth of precipitation are totaled for the month, and the average concentration for the month, $\overline{C}$, is determined by:

$$\overline{C} = \frac{\Sigma D}{\Sigma P} \times 1000$$

The February 1964 average concentrations and total depositions are given in table 2.

---

[3] See discussion of spring rise in report by Lockhart, *et al.*, in this issue, page 255.

TABLE 1.—FISSION PRODUCTS GROSS BETA ACTIVITY IN SURFACE AIR, FEBRUARY 1964

[Concentrations in pc/m³]

Station location		Number of samples	Maximum	Minimum	Average [a]
Alabama:	Montgomery [b]	19	1.69	0.27	1.22
Alaska:	Adak	28	1.07	<0.27	0.47
	Anchorage	28	1.47	0.11	0.68
	Attu	19	0.84	0.18	0.55
	Fairbanks	4	0.92	0.56	0.66
	Juneau	27	1.34	<0.10	0.41
	Kodiak	20	1.48	<0.10	0.55
	Nome	20	0.62	<0.10	0.39
	Point Barrow	28	1.02	0.12	0.36
	St. Paul Island	11	1.06	0.17	0.53
Ariz:	Phoenix	23	4.35	1.20	2.53
Ark:	Little Rock	27	2.23	0.43	1.17
Calif:	Berkeley	18	3.13	0.51	1.56
	Los Angeles	19	4.15	0.92	2.80
Canal Zone:	Ancon	15	0.90	0.12	0.54
Colo:	Denver	26	3.06	0.41	1.47
Conn:	Hartford	29	1.60	0.27	0.99
Del:	Dover	17	2.01	0.79	1.16
D. C:	Washington	27	2.36	0.20	1.12
Fla:	Jacksonville	29	3.63	0.40	1.44
	Miami	28	3.92	0.87	2.03
Ga:	Atlanta	22	1.50	0.40	0.77
Guam:	Agana	29	2.81	0.42	1.09
Hawaii:	Honolulu	29	1.90	0.25	0.90
Idaho:	Boise	29	2.65	0.15	0.95
Ill:	Springfield	22	1.23	0.32	0.70
Ind:	Indianapolis	28	1.44	0.34	0.92
Iowa:	Iowa City	28	1.35	0.30	0.81
Kans:	Topeka	26	2.59	0.46	1.14
Ky:	Frankfort	29	2.98	0.33	1.01
La:	New Orleans	29	1.86	0.44	1.07
Maine:	Augusta	29	1.85	0.24	1.13
	Presque Isle	25	1.49	0.33	0.90
Md:	Baltimore	19	1.61	0.33	0.93
	Rockville	15	3.35	<0.10	1.39
Mass:	Lawrence	29	1.83	0.22	1.11
	Winchester	26	1.54	0.14	0.97
Mich:	Lansing	29	1.92	0.65	1.25
Minn:	Minneapolis	28	2.03	0.31	0.84
Miss:	Jackson	29	2.29	0.41	1.27
	Pascagoula	0	—	—	—
Mo:	Jefferson City	28	1.57	0.35	0.72
Mont:	Helena	28	2.60	0.41	1.00
Nebr:	Lincoln	13	1.63	<0.10	0.95
Nev:	Las Vegas	25	5.20	0.55	2.50
N. H:	Concord	17	1.98	0.25	1.37
N. J:	Trenton	27	1.71	0.20	1.06
N. Mex:	Sante Fe	29	4.46	0.39	1.95
N. Y:	Albany	19	1.15	0.22	0.82
	Buffalo	27	1.72	0.48	1.19
	New York	27	1.78	0.39	0.99
N. C:	Gastonia	29	1.92	0.32	0.92
N. Dak:	Bismarck	29	2.30	0.45	0.91
Ohio:	Cincinnati	19	1.49	0.39	0.96
	Columbus	25	2.38	0.31	1.10
	Painesville	28	2.55	0.60	1.59
Okla:	Oklahoma	26	1.58	0.40	0.94
	Ponca City	27	1.24	0.21	0.64
Ore:	Portland	19	3.31	0.57	1.76
Pa:	Harrisburg	27	1.80	<0.10	0.69
P. R:	San Juan	29	1.22	0.23	0.62
R. I:	Providence	25	1.59	0.40	1.05
S. C:	Columbia	29	1.74	0.38	0.88
S. Dak:	Pierre	29	2.33	0.44	0.93
Tenn:	Nashville	29	2.98	0.42	1.05
Tex:	Austin	29	2.46	0.43	1.36
	El Paso	29	4.52	0.65	2.03
Utah:	Salt Lake City	28	3.37	0.44	1.31
Vt:	Barre	29	1.98	0.54	1.30
Va:	Richmond	29	1.60	0.26	0.78
Wash:	Seattle	29	1.36	0.15	0.69
W. Va:	Charleston	28	1.53	0.29	0.88
Wisc:	Madison	29	1.60	0.51	1.02
Wyo:	Cheyenne	27	3.46	0.40	1.61
Network summary		1829	5.20	<0.10	1.09

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed before the average.

[b] New station, began operation February 1, 1964.

TABLE 2.—GROSS BETA ACTIVITY IN PRECIPITATION, FEBRUARY 1964

Station location		Average concentration [a] (pc/liter)	Total deposition [a] (nc/m²)
Alaska:			
	Anchorage	260	1.9
	Fairbanks	[b]—	—
	Juneau	240	81.2
Ark:	Little Rock	280	22.2
Calif:	Berkeley	400	1.9
	Los Angeles	—	—
Colo:	Denver	—	—
Conn:	Hartford	450	15.6
D. C:	Washington	470	33.2
Fla:	Jacksonville	220	21.5
	Miami	290	29.5
Ga:	Atlanta	280	10.1
Hawaii:	Honolulu	300	3.9
Idaho:	Boise	—	—
Ill:	Springfield	330	5.0
Ind:	Indianapolis	420	21.6
Iowa:	Iowa City	380	8.3
Kans:	Topeka	1,000	12.0
Ky:	Frankfort	400	20.0
La:	New Orleans	230	24.7
Maine:	Augusta	370	25.8
	Presque Isle	—	—
Md:	Baltimore	560	11.2
Mass:	Lawrence	350	36.0
	Winchester	500	39.3
Mich:	Lansing	500	6.5
Minn:	Minneapolis	—	—
Miss:	Jackson	520	21.2
Mo:	Jefferson City	310	17.7
Mont:	Helena	990	13.8
Nebr:	Lincoln	—	—
Nev:	Las Vegas	—	—
N. J:	Trenton	390	6.7
N. Mex:	Santa Fe	560	16.7
N. Y:	Albany	230	9.2
	Buffalo	370	2.2
N. C:	Gastonia	260	33.5
N. Dak:	Bismarck	200	4.0
Ohio:			
	Columbus	880	28.2
	Painesville	800	33.7
Okla:	Oklahoma City	220	8.5
	Ponca City	440	8.3
Ore:	Portland	310	8.4
Pa:	Harrisburg	200	5.4
P. R:	San Juan	200	3.7
R. I:	Providence	500	16.0
S. C:	Columbia	340	41.4
S. Dak:	Pierre	—	—
Tenn:	Nashville	490	40.0
Tex:	Austin	300	12.0
	El Paso	—	—
Utah:	Salt Lake City	1,700	13.4
Vt:	Barre	480	9.6
Va:	Richmond	250	28.1
Wash:	Seattle	470	10.3
W. Va:	Charleston	440	32.3
Wisc:	Madison	500	2.4
Wyo:	Cheyenne	500	0.7

[a] The minimum concentration reported for a single sample is 200 pc/liter. If the individual sample has a concentration of <200 pc/liter, the deposition for that sample is calculated by $D=\frac{C\times P}{1000}=<0.2P$ in nc/m² (see text). A less-than sign (<) is used with the monthly total deposition whenever the sum of the individual less-than values represents more than 10 percent of the total. The monthly average concentration is then calculated as described in text, retaining the less-than sign when used with the total deposition.

[b] Dash indicates no evaporated sample received.

9b

2. Canadian Air Monitoring Program[4]
February 1964

Department of National Health and Welfare

As part of its Radioactive Fallout Study Program, the Radiation Protection Division of the Canadian Department of National Health and Welfare monitors air and precipitation. Twenty-four collection stations are located at airports (see figure 2), where the sampling equipment is operated by personnel from the Meteorological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*3–7*).

Air

Each air sample involves the collection of particulates from about 650 cubic meters of air drawn through a high-efficiency 4-inch-diameter filter during a 24-hour period. These filters are sent daily to the Radiation Protection Division Laboratory in Ottawa. At the laboratory, a 2-inch-diameter disk is cut from each filter and counted with a thin-end-window, gas flow Geiger-Mueller counter system, calibrated with a Sr^{90}–Y^{90} standard. Four successive measurements are made on each filter to permit correction for natural activities and for the decay of short-lived fission products. The results are extrapolated to the end of the sampling period. Canadian air data for February 1964 are given in table 3 and presented in conjunction with U.S. and Mexican data by an isogram map (figure 4).

TABLE 3.—GROSS BETA ACTIVITY IN AIR, CANADA, FEBRUARY 1964

[Average concentrations in pc/m³]

Station	Number of samples	Maximum	Minimum	Average
Calgary	28	3.1	0.4	1.3
Coral Harbour	26	1.8	0.1	1.0
Edmonton	29	2.3	0.4	1.0
Ft. Churchill	29	1.4	0.4	0.9
Ft. William	29	2.3	0.2	1.1
Fredericton	29	1.7	0.1	1.0
Goose Bay	29	1.5	0.3	1.0
Halifax	27	2.0	0.2	1.2
Inuvik	29	2.0	0.5	0.9
Montreal	29	2.0	0.3	1.2
Moosonee	29	2.3	0.6	1.4
Ottawa	29	1.6	0.4	1.1
Quebec	28	1.6	0.4	1.2
Regina	29	1.8	0.5	0.9
Resolute	29	1.6	0.1	0.8
St. John's, Nfld	27	1.8	0.1	0.9
Saskatoon	29	1.9	0.5	1.1
Sault Ste. Marie	28	1.8	0.6	1.1
Toronto	29	0.9	0.1	0.4
Vancouver	27	2.3	0.1	0.9
Whitehorse	29	1.8	0.2	0.8
Windsor	23	1.8	0.4	1.2
Winnipeg	29	3.4	0.4	1.2
Yellowknife	28	1.7	0.4	0.9
Network summary	677	3.4	0.1	1.0

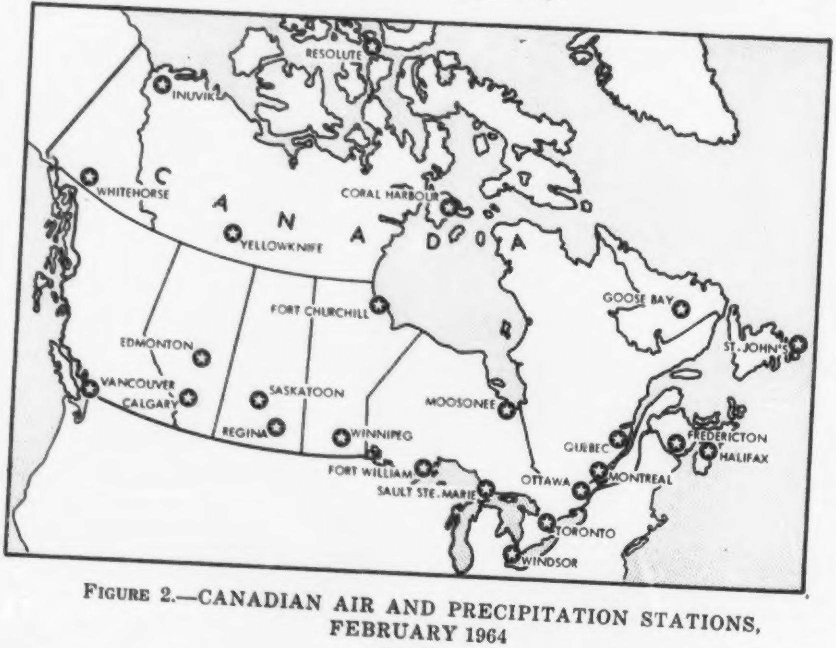

FIGURE 2.—CANADIAN AIR AND PRECIPITATION STATIONS, FEBRUARY 1964

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[4] Data from *Radiation Protection Programs*, 3:11–24, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (March 1964).

Precipitation

The amount of radioactive fallout deposited on the ground is determined from measurements on material collected in special polyethylene-lined rainfall pots. The collection period for each sample is one month. After transfer of the water to the sample container, the polyethylene liner is removed, packed with the sample, and sent to the laboratory.

Strontium and cesium carriers are added to all samples on arrival at the laboratory. Other carriers are also added to selected samples according to the specific radionuclides to be determined. The samples are then filtered and the filtrate evaporated to near dryness. The filter paper containing insoluble matter is ignited together with the polyethylene liner at 450° C. The ash is combined with the soluble fraction, transferred to a glass planchet, evaporated under an infra-red lamp and then counted with a thin-end-window Geiger-Mueller counter calibrated with a Sr^{90}–Y^{90} source. Gross beta activities for February 1964 samples are given in table 4. Radionuclide analyses appear quarterly.

TABLE 4.—GROSS BETA ACTIVITY IN PRECIPITATION, CANADA, FEBRUARY 1964

Station	Total beta activity	
	pc/liter	nc/m^2
Calgary	[a]	7.3
Coral Harbour	916	20.9
Edmonton	789	8.4
Ft. Churchill	413	4.1
Ft. William	418	4.2
Fredericton	165	16.1
Goose Bay	124	10.9
Halifax	299	55.5
Inuvik	402	6.4
Montreal	346	10.8
Moosonee	254	9.3
Ottawa	232	7.3
Quebec	591	29.0
Regina	432	7.0
Resolute	432	18.6
St. John's, Nfld	432	38.7
Saskatoon	385	4.9
Sault Ste. Marie	411	12.3
Toronto	421	11.2
Vancouver	642	45.2
Whitehorse	299	4.4
Windsor	876	17.8
Winnipeg	801	4.5
Yellowknife	328	4.8
Average	444	15.0

[a] Trace precipitation.

3. Mexican Air Monitoring Program February 1964

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN) through its Radiological Protection Program (RPP) in 1961. The network consists of 17 stations (see figure 3), twelve of which are located at airports and operated by airline personnel. The remaining five stations are located at Mexico City, Mérida, Veracruz, San Luis Potosí and Ensenada. Staff members of the RPP operate the station at Mexico while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air for 24 hours a day, 3 or 4 days a week, at the rate of approximately 1,200 cubic meters per day, through a high-efficiency, 6- x 8-inch glass fiber filter, using high volume samplers. After each 24-hour sampling period, the filter is removed and forwarded via air mail to the "Laboratorio de Estudios Sobre Contaminación Radiactive", CNEN, in Mexico City for assay of gross beta activity. A minimum of 3 or 4 days after collection is allowed for decay of radon and thoron daughter natural radioactivity. Data are not extrapolated to time of collection.

Results

The maximum, minimum and average fission product beta concentrations in surface air during February 1964 are presented in table 5. The data are also represented in the beta activity isogram map of North America, figure 4.

TABLE 5.—GROSS BETA ACTIVITY OF AIRBORNE PARTICULATES, MEXICO, FEBRUARY 1964

[Concentrations in pc/m^3]

Station	Number of samples	Maximum	Minimum	Average
Acapulco	17	4.8	1.4	2.5
Ciudad Juárez	19	6.4	0.7	1.8
Chihuahua	12	3.2	0.3	1.1
Ensenada	9	3.3	1.2	2.1
Guadalajara [a]	0	—	—	—
Guaymas [a]	0	—	—	—
La Paz	16	4.0	1.6	3.6
Matamoros [a]	0	—	—	—
Mazatlán [a]	0	—	—	—
Mérida	8	2.3	0.4	1.4
Mexico City	17	1.3	0.1	0.5
Nuevo Laredo [a]	3	2.3	1.0	—
San Luis Potosí	10	2.4	0.3	1.3
Tampico [a]	0	—	—	—
Torreón	15	3.5	0.3	1.8
Tuxtla Gutiérrez [a]	0	—	—	—
Veracruz [a]	0	—	—	—

[a] Temporarily shut down.

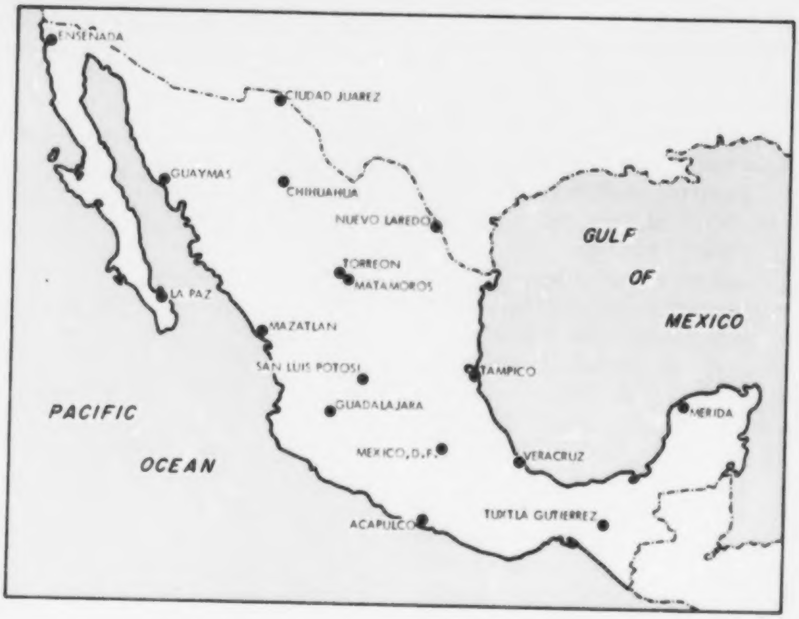

FIGURE 3.—FALLOUT NETWORK SAMPLING STATIONS IN MEXICO

4. Pan American Air Sampling Program February 1964

Pan American Health Organization and Public Health Service

Gross beta activity in air is monitored by three countries in South America under the auspices of a collaborative program developed by the Pan American Health Organization and the Public Health Service (PHS) for assisting countries of the Americas in developing radiological health programs. The sampling equipment and analytical services are provided by the Division of the Radiological Health, PHS, and are identical with those employed for the Radiation Surveillance Network.

The three air sampling stations included in the program are operated by the technical staff of the Ministry of Health in each country. The station in Santiago, Chile is operated by the Occupational Health Service; in Lima, Peru by the Institute of Occupational Health; and in Caracas, Venezuela by the Venezuelan Institute for Scientific Investigations. The Caracas station began operation in November 1962 and the other two stations were started the following month.

The February 1964 air monitoring results from the three participating countries are given in table 6. The Caracas station is shown on the gross beta concentration isogram map (figure 4) and its February average, 0.73 pc/m^3 (after adjustment by the RSN intercalibration factor[5]), was used in estimating the position of the 0.5 pc/m^3 isogram.

TABLE 6.—GROSS BETA ACTIVITY IN AIR, FEBRUARY 1964

[Concentrations in pc/m^3]

Sampling stations	No. of samples	Maximum	Minimum	Average[a]
Caracas, Venezuela	20	0.87	0.28	0.57
Lima, Peru	0	—	—	—
Santiago, Chile	15	0.12	<0.10	0.10

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values of <0.10 are assumed to be 0.10 for averaging purposes. If the <0.10 values represent more than 10 percent of the average, a less-than sign is placed in front of the average.

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[5] The RSN factor is 1.28.

5. Gross Beta Activity in Air, North America, February 1964

Beginning with January 1963 data, monthly average concentrations of airborne gross beta activity in Canada and the United States have been presented in combined form as isogram maps of most of North America.[6] The data from the Radiation Surveillance Network and the Canadian Air Network were adjusted to each other by means of an intercalibration factor derived by Lockhart and Patterson (*8*).

With the formation of the Mexican Air monitoring program, new intercalibration ratios were determined, this time including the Canadian Network, Radiation Surveillance Network, National Air Sampling Network, the HASL 80th Meridian Network, and the Mexican Network (*9*). The new intercalibration factors include some changes in standardization in both the RSN and the Canadian Air Network, effective September 1963. The intercalibration factors are, therefore, not the same as were previously used.

Figure 4 shows the February 1964 activity in air throughout North America based on the data from the Canadian Air Monitoring Program, the Radiation Surveillance Network and Mexican Air Monitoring program. An intercalibration factor of 1.28 was applied to the RSN data and the Mexican data were multiplied by 0.81 in order to adjust them to Canadian data.

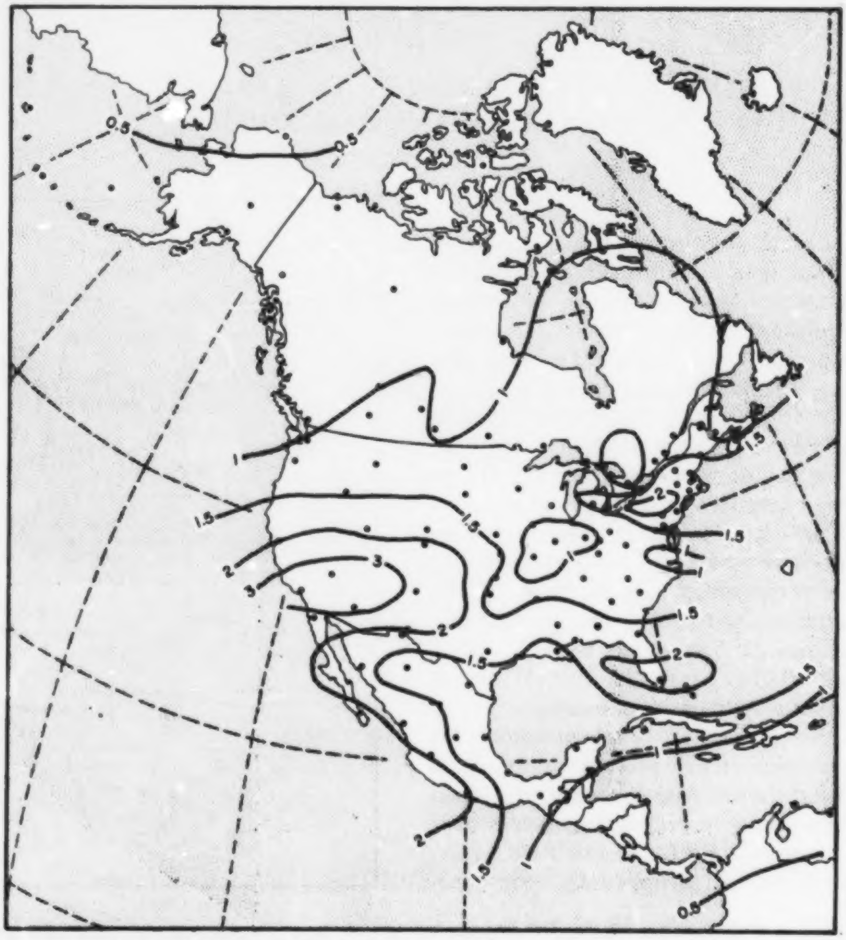

Figure 4.—ISOGRAMS OF AVERAGE GROSS BETA CONCENTRATIONS IN AIR (pc/m^3) THROUGHOUT NORTH AMERICA, FEBRUARY 1964

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[6] The January through December 1963 Isogram Maps were published in the May 1963 through April 1964 issues of *Radiological Health Data*.

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FISSION PRODUCT GAMMA ACTIVITY IN AIR—80TH MERIDIAN NETWORK, DECEMBER 1963

W. R. Collins, Jr.[1]

The results of total gamma activity measurements on ground level air filter samples taken at 80th Meridian stations (see figure 1) during December 1963 are listed in table 1, together with average monthly activities for each site and the ratios of photons with energies in excess of 1 Mev to total photon activity. Details of sampling procedure and analytical methodology have previously been described (*1, 2*).

The average activity concentrations are also plotted in figure 2 as an activity-latitude profile. The December results show slight decreases in air activity concentrations at most of the sites with a maximum of 1.2 γ/min/m^3 (gamma photons per minute per cubic meter) and a minimum of 0.018 γ/min/m^3 occurring at Miami and Punta Arenas, respectively.

Average monthly activity concentrations for the two hemispheres are plotted in figure 3. From these data a gradual decrease in air activity concentrations in both hemispheres over the year is apparent. By December 1963, activity concentrations had dropped to about one-

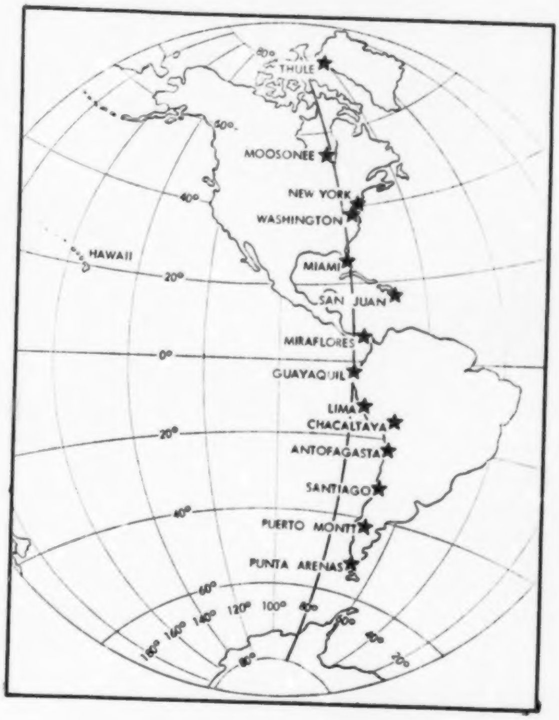

FIGURE 1.—80TH MERIDIAN NETWORK SAMPLING STATIONS

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TABLE 1.—ACTIVITY OF SURFACE AIR, 80TH MERIDIAN NETWORK, DECEMBER 1963

Sampling station	Sampling period (dates—noon to noon)	Gamma activity (photons/min/m³)		Gamma ratio $\left(\frac{\gamma > 1 \text{ Mev}}{\text{total } \gamma}\right)$
		Filter	Average for month	
Thule, Greenland	1-8	0.814		0.055
	8-15	0.718		0.056
	15-22	1.17		0.056
	22-1/1	0.899	0.900	0.037
Moosonee, Canada	1-8	0.604		0.059
	8-15	0.636		0.054
	15-22	0.448		0.064
	22-1/1	0.423	0.528	0.062
New York, New York	1-8	0.795		0.069
	8-15	0.478		0.065
	22-1/1	0.656	0.643	0.065
Washington, D. C	1-8	0.567		0.067
	8-15	0.305		0.074
	15-22	0.553		0.065
	22-1/1	0.602	0.507	0.063
Miami, Florida	1-8	1.58		0.057
	8-15	1.39		0.063
	15-22	1.23		0.065
	22-1/1	0.728	1.23	0.068
Mauna Loa, Hawaii	1-8	0.339		0.077
	8-15	0.523		0.065
	15-22	0.252		0.052
	22-1/1	0.377	0.373	0.064
San Juan, Puerto Rico	1-8	0.390		0.061
	8-15	0.334		0.049
	15-22	0.348		0.058
	22-1/1	0.205	0.319	0.060
Miraflores, Canal Zone	1-8	0.253		0.052
	8-15	0.173		0.052
	15-22	0.338		0.065
	22-1/1	0.233	0.249	0.067
Guayaquil, Ecuador	1-8	0.0367		0.056
	8-15	0.0688		0.073
	15-22	0.0556		0.079
	22-1/1	0.0524	0.0534	0.061
Lima, Peru	1-8	0.126		0.060
	8-15	0.120		0.062
	15-22	0.121		0.054
	22-1/1	0.104	0.118	0.062
Chacaltaya, Bolivia	1-8	0.0177		0.025
	8-15	0.0187		0.052
	15-22	0.0326		0.046
	22-1/1	0.0598	0.0322	0.060
Antofagasta, Chile	1-8	0.0704		0.060
	8-15	0.0641		0.055
	15-22	0.0790		0.075
	22-1/1	0.0786	0.0730	0.061
Santiago, Chile	1-8	0.0911		0.074
	8-15	0.0641		0.076
	15-22	0.0790		0.080
	22-1/1	0.0786	0.0745	0.074
Puerto Montt, Chile	1-8	0.0460		0.067
	8-15	0.0391		0.078
	22-1/1	0.0416	0.0422	0.045
Punta Arenas, Chile	1-8	0.0195		0.115
	8-15	0.0128		0.044
	22-1/1	0.0201	0.0175	0.053

tenth of the January levels, with averages of 0.73 γ/min/m³ and 0.062 γ/min/m³ in the Northern and Southern Hemisphere, respectively. During the year the greatest differences in the hemispheric averages occurred during April and May, when the spring maximum in the Northern Hemisphere coincided with the fall minimum in the Southern Hemisphere and the smallest divergences were in September and October when the seasonal effects were reversed.

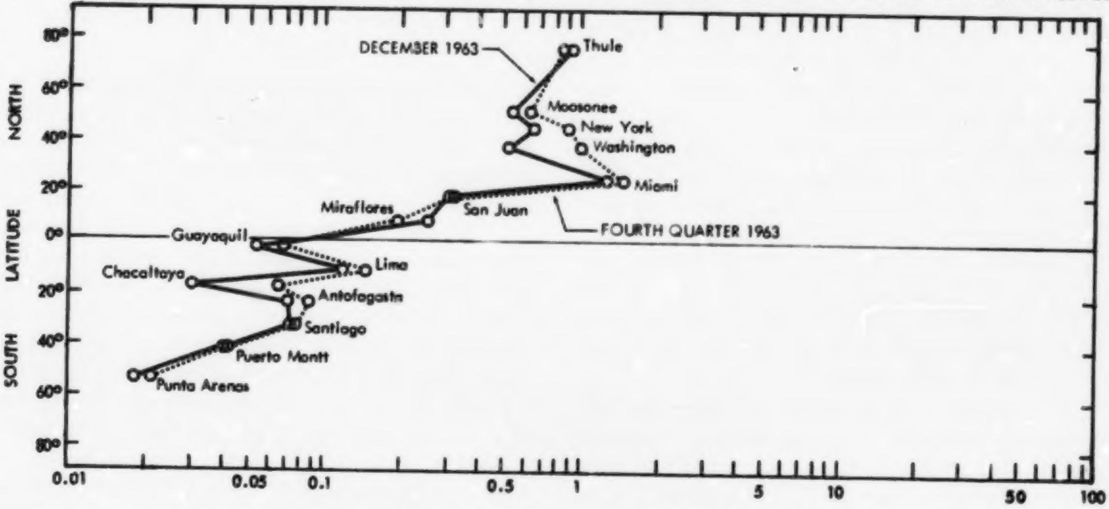

FIGURE 2.—PROFILE OF SURFACE AIR GAMMA ACTIVITY, FOURTH QUARTER AND DECEMBER 1963

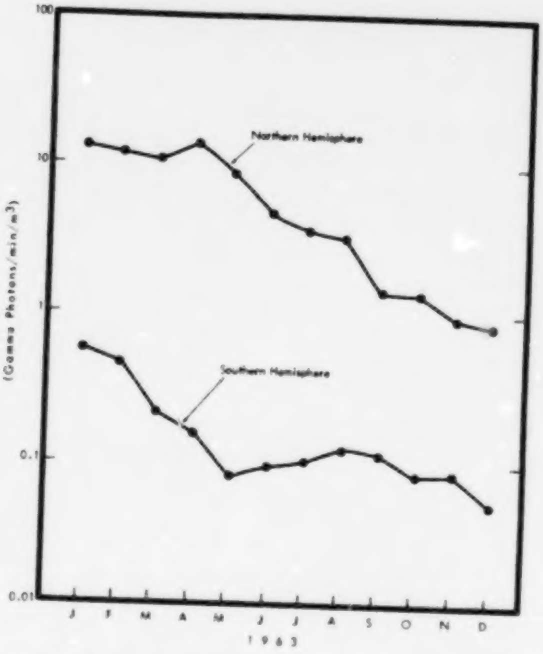

FIGURE 3.—AVERAGE MONTHLY GAMMA ACTIVITY IN GROUND LEVEL AIR DURING 1963

Use of the Photon Ratio

Since January 1963 the ratio of photons with energies in excess of 1 Mev to total photon activity has been measured routinely in the 80th Meridian samples as a means of detecting the presence of fresh debris. The method was based on experiments conducted at the Health and Safety Laboratory which showed that in fission products produced by thermal neutron irradiation of enriched uranium, the fraction of photons with energies in excess of 1 Mev decreased rapidly from about 0.2 to 0.01 during the first 5 months after irradiation and then did not vary from the latter value for at least another 10 months (*1*). These results were presented in the January 1963 80th Meridian Report and are updated in curve A of figure 4. From this plot it would be expected that samples having ratios higher than 0.01 would contain some proportion of fresh debris.

This change in ratio apparently does not hold for actual samples of thermonuclear weapons fallout. For example, the ratios for the December 80th Meridian sample listed in table 1 average 0.060 and 0.063 for the Northern and Southern Hemispheres, respectively. These values are consistent with the gradual increase in the ratios that has been noted in 80th Meridian samples since the spring of the year. This is shown in figure 4, where average monthly ratios for the year are plotted for comparison with the theoretical ratios. A mean production date of October 8, 1962, has been assumed for the fission products. It is apparent that the ratios are generally higher than would be predicted by the results of the thermal irradiation experiment (curve A in figure 4). This would still be true even if all the activity were attributed to the last known test in 1962.

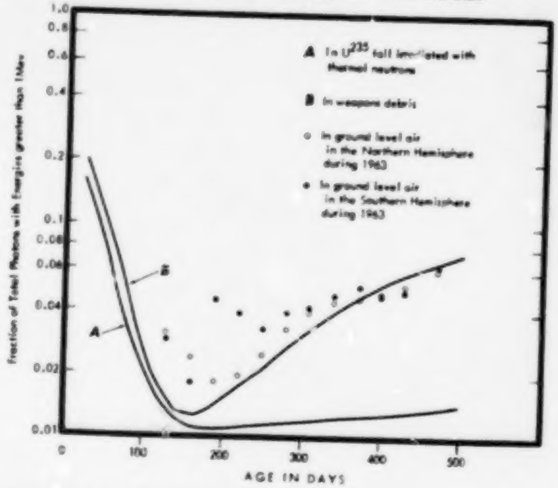

FIGURE 4.—FRACTIONS OF TOTAL GAMMA PHOTONS WITH ENERGIES IN EXCESS OF 1 MEV IN THEORETICAL AND ACTUAL FISSION PRODUCT SAMPLES AS A FUNCTION OF AGE

According to weapons yield data listed by Hallden *et al.*, (*3*), from 4.9 to 6.4 times more Ru^{106} atoms are produced by thermonuclear detonations than by thermal neutron fission. The Ru^{106}–Rh^{106} pair emits gamma radiation above 1 Mev and the possibility exists that this nuclide might be affecting the greater-than-1-Mev to total photon ratio found in the 80th Meridian samples. This was investigated by correcting the thermal fission data (illustrated in curve A of figure 4) for the deficiency in Ru^{106}. The results of these calculations are illustrated in curve B. The two curves are similar for fresh material, but as the relative contribution of Ru^{106} to total activity increases, curve B increases much more sharply than curve A. The validity of this estimate will be known when the radiochemical data become available.

Conclusions

The high ratios obtained for the April and May 80th Meridian samples were attributed in part to the presence of Sb^{124} (*4*). In addition, there is evidence that Y^{88}, Mn^{54}, Fe^{59}, and other activation products may have elevated or depressed the ratios from the expected values. Further information on this subject must also await the results of radiochemical analysis. However, despite the possible influences of activation products, it is apparent from figure 4 that the measured ratios for the 1963 80th Meridian samples conform more closely to the weapons debris curve B than to the thermal irradiation curve A.

Since curve B would indicate that both fresh and aged debris could yield high ratios, future detection of fresh debris in 80th Meridian samples must be based on month-to-month changes in the ratio, increases in total activity levels and gamma spectrometric identification of Ba^{140} or other short-lived nuclides in the samples. The photon energy ratio will therefore no longer be routinely reported.

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SUMMARY REPORT ON AIRBORNE FISSION PRODUCTS ALONG THE 80TH MERIDIAN (WEST), 1957-1962[1]

L. B. Lockhart, Jr., R. L. Patterson, Jr.,
A. W. Saunders, Jr. and R. W. Black[2]

In early 1956, with the increasing concern about the spread of contamination from nuclear weapons tests and a rising interest in the use of airborne radioactivity as a tracer for atmospheric processes, representatives of the U.S. Naval Research Laboratory (NRL), the U.S. Atomic Energy Commission and the U.S. Weather Bureau considered the feasibility and desirability of establishing a network of stations along the 80th Meridian (West) for making measurements of atmospheric radioactivity. Such a program was put into operation in 1956 with partial financial support by the Division of Biology and Medicine, U.S. AEC, and with the cooperation of a number of agencies and organizations located in countries along or near the 80th Meridian.

This network was in continuous operation by NRL during the periods of the International Geophysical Year and International Geophysical Cooperation—1959 until its voluntary transfer to the Health and Safety Laboratory of the U.S. Atomic Energy Commission on January 1, 1963.

Operation of the NRL 80th Meridian Air Sampling Program took place during an interesting period of the atomic age and the development of nuclear weaponry. It covered the nearly three-year moratorium on nuclear testing as well as the episodes of intensive testing of high yield devices both before and after the moratorium. Data collected during this program have helped substantiate a number of concepts regarding atmospheric mixing processes and residence times of radioactive particulate matter in the atmosphere.

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[1] Partial financial support of this program has been provided by the Fallout Studies Branch, Division of Biology and Medicine, U.S. Atomic Energy Commission.

[2] Dr. Lockhart is Head of the Physical Chemistry Branch, and Mr. Patterson is Head and Messrs. Saunders and Black are staff members of the Radiochemistry Section, Physical Chemistry Branch, U.S. Naval Research Laboratory, Washington, D.C. Mr. Black has recently transferred to the Analytical Chemistry Branch, Metallurgy Division, NRL.

This report summarizes measurements of both gross beta activity and Sr^{90} activity in the air at ground level along the 80th Meridian during the period 1957 through 1962. More detailed results and interpretations are given for the collections of radioactivity made in 1962.

Experimental Procedures

Representative samples of the radioactive aerosols dispersed in the lower atmosphere were collected at the various sites by drawing ground-level air through highly efficient cellulose-asbestos filters 8 inches in diameter at the rate of about 1200 cubic meters per day. Continuous sampling was done at each site but the schedule of filter changes varied from daily, during 1957 through 1959, to thrice-weekly during 1960, and once per week during 1961 and 1962. Samples were returned to NRL by air for assay for gross beta activity and for radiochemical analysis.

TABLE 1.—RADIOCHEMICAL ANALYSES OF BIMONTHLY COMPOSITE AIR-FILTER COLLECTIONS, 80TH MERIDIAN (WEST) SAMPLING PROGRAM, 1962

[Concentrations in pc/m³][a]

Station	Sampling period		Gross beta	Ce^{141}	Sr^{89}	Y^{91}	Ce^{144}	Pm^{147}	Sr^{90}	Cs^{137}	Pb^{210}
	1962	Days sampled [b]									
Thule, Greenland (elevation 259 meters)	Jan-Feb	49	4.60	[c] 0.29	0.653	1.076	0.581	0.095	0.0167	0.0251	0.00112
	Mar-Apr	63	6.01	[d] *	0.540	0.923	0.878	0.135	0.0297	0.0477	0.00783
	May-June	56	2.93	*	0.190	0.311	0.518	0.100	0.0226	0.0380	0.00459
	July-Aug	63	1.80	*	0.071	0.120	0.331	0.084	0.0149	0.0274	0.00344
	Sept-Oct	63	1.57	[c] 0.26	0.108	0.181	0.203	0.068	0.0077	0.0126	0.00290
	Nov-Dec	60	3.63	[c] 0.36	0.423	0.563	0.385	0.104	0.0130	0.0190	0.00428
Moosonee, Canada (elevation 10 meters)	Jan-Feb	57	3.93	[c] 0.27	0.500	0.905	0.473	0.067	0.0134	0.0164	0.00698
	Mar-Apr	63	5.96	*	0.509	0.738	0.779	0.121	0.0264	0.0299	0.00860
	May-June	56	5.60	*	0.297	0.482	0.756	0.144	0.0327	0.0468	0.00585
	July-Aug	63	3.02	[c] 0.035	0.129	0.242	0.509	0.125	0.0231	0.0405	0.00165
	Sept-Oct	63	1.99	0.18	0.130	0.209	0.229	0.063	0.00904	0.0158	0.00500
	Nov-Dec	63	3.49	[c] 0.65	0.374	0.513	0.297	0.063	0.00941	0.0158	0.00936
Washington, D. C (elevation 82 meters)	Jan-Feb	63	6.71	[c] 1.15	0.837	1.539	0.729	0.111	0.0199	0.0392	0.00272
	Mar-Apr	63	7.11	*	0.653	0.994	1.013	0.154	0.0352	[f] —	0.00815
	May-June	56	6.62	[c] 0.60	0.403	0.635	1.040	0.279	0.0399	0.0671	0.0145
	July-Aug	56	4.73	[c] 0.23	0.220	0.391	0.842	0.221	0.0405	0.0644	0.00518
	Sept-Oct	63	4.50	[c] 0.14	0.382	0.459	0.455	0.117	0.0161	0.0280	0.0164
	Nov-Dec	63	6.62	[c] 0.48	0.693	0.905	0.500	0.122	0.0155	0.0256	0.0198
Miami, Florida (elevation 4 meters)	Jan-Feb	63	7.70	[c] 1.05	0.882	1.841	0.815	0.125	0.0235	0.0177	0.00221
	Mar-Apr	63	10.91	*	0.941	1.805	1.296	0.243	0.0495	0.0504	0.00266
	May-June	56	4.88	*	0.310	0.549	0.761	0.173	0.0329	0.0288	0.00545
	July-Aug	63	1.68	*	0.086	0.153	0.280	0.073	0.0111	0.0132	0.00434
	Sept-Oct	63	3.25	[c] 0.19	0.305	0.531	0.327	0.068	0.0109	0.0095	0.00473
	Nov-Dec	63	11.12	[c] 1.91	1.098	1.467	0.765	0.180	0.0257	0.0255	0.00342
Mauna Loa, Hawaii (elevation 3394 meters)	Jan-Feb	63	5.81	[c] 0.77	0.905	1.143	0.563	0.107	0.0220	0.0357	0.00258
	Mar-Apr	63	7.29	*	0.783	1.323	1.121	0.192	0.0393	0.0666	0.00846
	May-June	56	6.03	*	0.441	0.639	0.887	0.213	0.0366	0.0653	0.00716
	July-Aug	53	3.30	*	0.244	0.391	0.513	0.137	0.0195	0.0370	0.00756
	Sept-Oct	56	2.12	*	0.202	0.243	0.204	0.0491	0.00918	0.01305	0.00409
	Nov-Dec	54	5.67	[c] 1.02	0.738	0.891	0.477	0.117	0.0176	0.0257	0.00603
Santiago, Chile (elevation 520 meters)	Jan-Feb	48	0.07	[c] 0.0027	[c] 0.0026	[c] 0.0015	0.00576	0.0072	0.00321	0.00648	0.00698
	Mar-Apr	63	0.04	*	[c] 0.0007	[c] 0.0010	0.00318	0.0039	0.00162	0.00385	0.00738
	May-June	42	0.42	[c] 0.146	0.0522	0.0702	0.0286	0.0103	0.00158	0.00399	0.0172
	July-Aug	[g]	—	—	—	—	—	—	—	—	—
	Sept-Oct	49	0.32	[c] 0.041	0.0204	0.0354	0.0388	0.0138	0.00244	0.00471	0.00612
	Nov-Dec	56	0.38	[c] 0.045	0.0217	0.0386	0.0540	0.0164	0.00304	0.00635	0.00513
Puerto Montt, Chile (elevation 5 meters)	Jan-Feb	56	0.03	[c] 0.0036	[c] 0.0071	[c] 0.0012	0.00395	0.00468	0.00215	0.00365	0.00084
	Mar-Apr	56	0.03	[c] 0.0006	[c] 0.0009	[c] 0.0006	0.00331	0.00415	0.00215	0.00374	0.00166
	May-June	63	0.05	[c] 0.0113	0.0081	0.0078	0.00414	0.00320	0.00106	0.00158	0.00290
	July-Aug	63	0.14	[c] 0.0338	0.0183	0.0259	0.01616	0.00806	0.00138	0.00176	0.00294
	Sept-Oct	56	0.09	[c] 0.0131	0.0105	0.0172	0.01706	0.00599	0.00147	0.00172	0.00185
	Nov-Dec	49	0.19	[c] 0.0113	0.0131	0.0232	0.0333	0.00954	0.00232	0.00331	0.00108
Punta Arenas, Chile (elevation 3 meters)	Jan-Feb	48	0.03	[c] 0.0023	[c] 0.0002	[c] 0.0003	0.00218	0.00320	0.00141	0.00307	0.00130
	Mar-Apr	63	0.01	[c] 0.0004	[c] 0.0002	0.0003	0.00150	0.00203	0.00103	0.00248	0.00082
	May-June	56	0.03	[c] 0.0063	[c] 0.0038	0.0049	0.00269	0.00234	0.00066	0.00186	0.00162
	July-Aug	63	0.07	[c] 0.0111	[c] 0.0060	0.0104	0.00743	0.00385	0.00065	0.00163	0.00232
	Sept-Oct	49	0.08	[c] 0.0081	[c] 0.0061	0.0114	0.01215	0.00393	0.00086	0.00175	0.00112
	Nov-Dec	56	0.08	[c] 0.0003	[c] 0.0057	0.0073	0.01148	0.00411	0.00087	0.00192	0.00059

[a] Counting error <2 percent (σ) unless otherwise indicated.
[b] Samples collected weekly but grouped by months.
[c] Indicates counting error >10 percent (σ).
[d] * indicates activity too low for measurement at time of analysis.
[e] Indicates counting error in range of 2–10 percent (σ).
[f] Dash indicates no analytical results reported.
[g] Insufficient samples received.

Radiochemical analyses were carried out by standardized techniques on composited samples from each site covering monthly (alternate months during 1959–1960) or bimonthly periods (1961–1962). This information has been reported in detail elsewhere (*1–9*). The results of the 1962 radiochemical analyses are presented in table 1 in units of picocuries per cubic meter of standard air corrected to the midpoint of the collection period. Some of the activity ratios of current interest are listed in table 2.

Gross Fission Products In the Air

Linear plots of the average gross beta activity versus time in months from 1957 through 1962 are presented in figure 1 for each of the currently operated 80th Meridian air sampling stations. Association of periods of high activity with periods of nuclear testing and with spring subsidence of radioactivity from the stratosphere is evident. It is apparent that during the 1959–1961 moratorium on nuclear testing a quite considerable decrease in the fission product component of the atmospheric radioactivity took place. The linear plots, however, do not permit much detail to be observed during periods of low activity.

The change in radioactivity with time at corresponding Northern and Southern Hemisphere sites (Miami and Antofagasta) is shown in figure 2 on a semi-log scale for the 1958–1962 period. The strong seasonal effect on the stratospheric deposition rate is apparent at Miami during 1960 and 1961 but less obvious at Antofagasta. Conclusions derived from the 1962 radiochemical data do not permit this lack of a well-defined seasonal effect in the Southern Hemisphere during past years to be attributed to the equatorial crossover of debris during the Northern Hemisphere spring maximum. It is suggested instead that the unsymmetrical distribution of stratospheric debris with only a small Antarctic component in a position to enter the troposphere in the spring could be responsible. This lack of symmetry could also account for the considerably lower activity at the southernmost sites in Chile relative to activities at comparable latitudes in the Northern Hemisphere or to those at lower latitudes in the Southern Hemisphere.

Strontium–90 In the Air At Ground Level

The concentrations of Sr^{90} that have been encountered in the ground-level air at a number of sites near the 80th Meridian during the course of this study are plotted on a logarithmic scale in figure 3.

There has been a definite spring maximum in the Northern Hemisphere every year regardless of the past history of nuclear testing. The timing of nuclear tests prevented an unequivocable assignment of these changes to changes in the stratospheric deposition rate until the moratorium on testing showed conclusively that such a seasonal pattern did exist. The seasonal cycle has its highest amplitude in the subtropical latitudes (e. g. Miami) and least in the arctic region; moreover, the time of arrival of the radioactivity maximum varies with the latitude, arriving earliest in the more southerly regions.

In the Southern Hemisphere the same pattern of behavior appeared to exist but it was not so well defined—perhaps, as hypothesized above, the results of a different spacial distribution of the stratospheric source.

The imbalance in the stratospheric inventories of Sr^{90} activity over the two hemispheres at the conclusion of nuclear testing in December 1962 was even greater than existed at the close of 1958. The pattern of behavior expected for the Sr^{90} concentrations in the ground level air is for the high levels reported in the Northern Hemisphere during 1963 to be followed by a marked reduction in the spring of 1964, with smaller changes thereafter. Some increases in the Sr^{90} concentration with time might be expected in the Southern Hemisphere for several years as the tropically-centered stratospheric source migrates or diffuses to a region where downward mixing into the troposphere is more effective. Moreover, there should then be a more evident seasonal cycle south of the Equator due to the larger amplitude of the seasonal effect of a stratospheric source over the mid-latitude or polar regions.

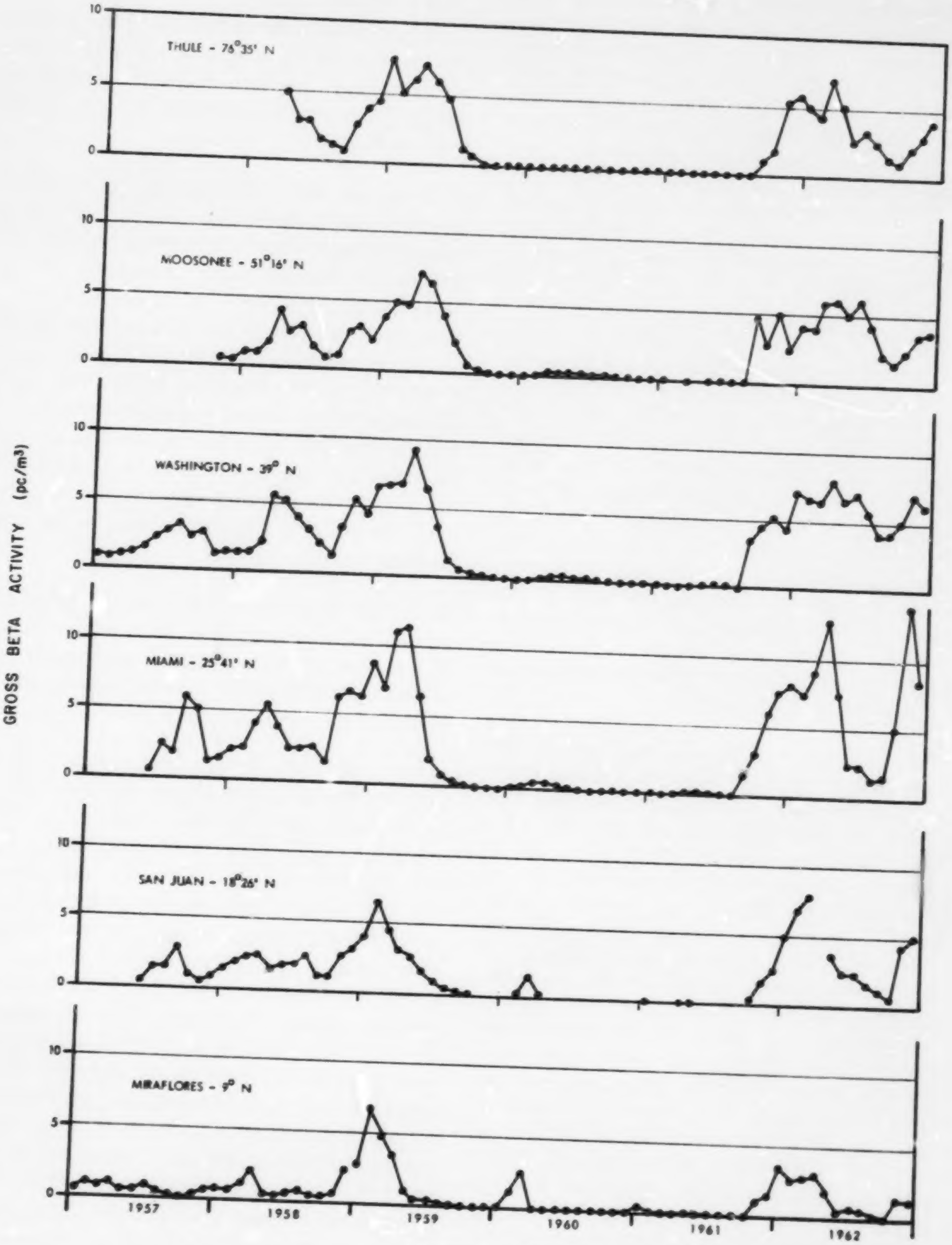

FIGURE 1.—FISSION PRODUCT BETA ACTIVITY IN AIR

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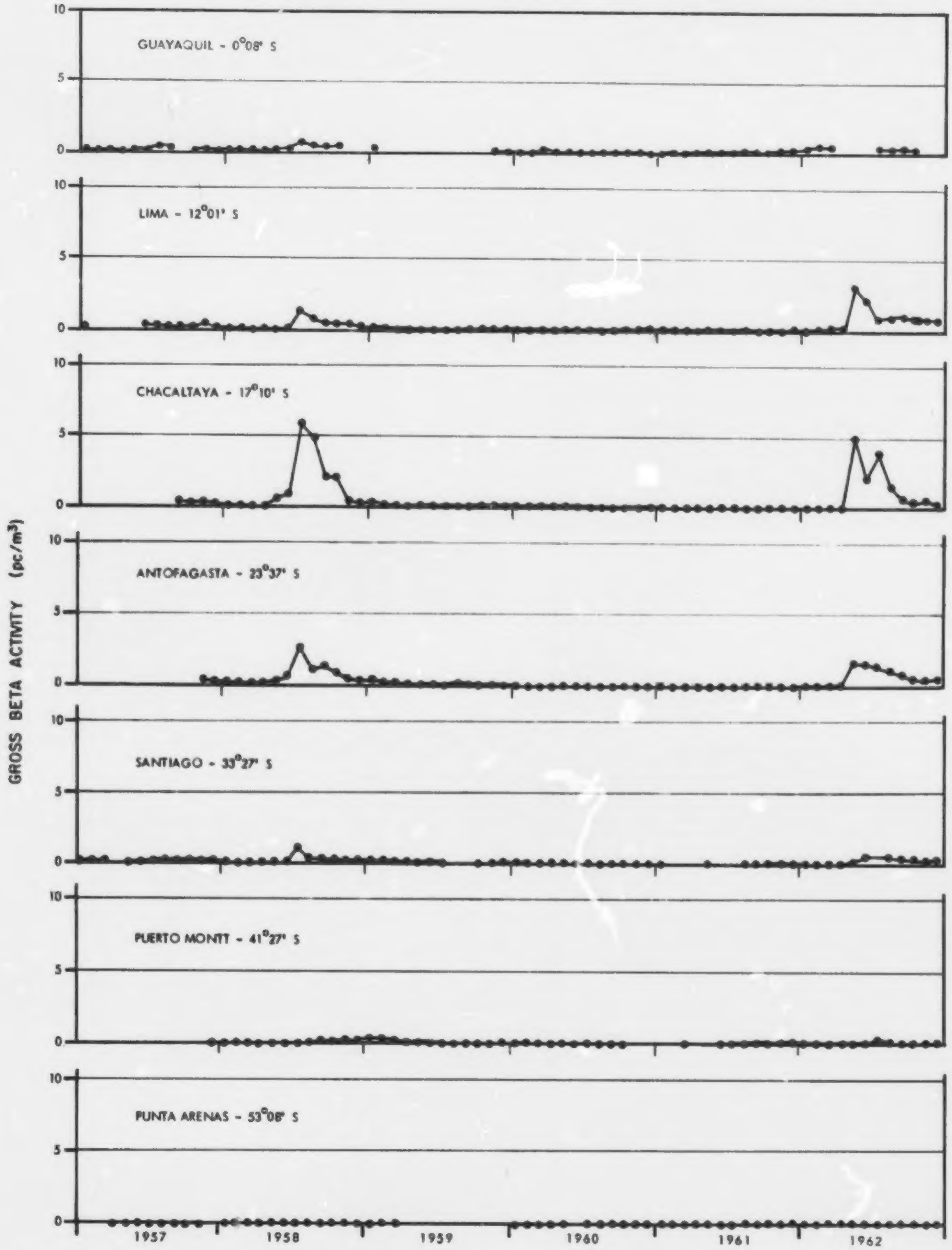

ALONG THE 80TH MERIDIAN (WEST), 1957–1962

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TABLE 2.—SELECTED RADIONUCLIDE ACTIVITY RATIOS, 80TH MERIDIAN SAMPLING PROGRAM, 1962

Station	Sampling period		[a] Ce^{141}/Ce^{144}	Sr^{89}/Sr^{90}	Y^{91}/Ce^{144}	Ce^{144}/Pm^{147}	Ce^{144}/Sr^{90}	Cs^{137}/Sr^{90}
	1962	Days sampled						
Thule, Greenland	Jan-Feb	49	0.5	39.1	1.85	6.1	34.8	1.90
	Mar-Apr	63	—	18.2	1.05	6.5	29.5	1.60
	May-June	56	—	8.4	0.60	5.2	22.9	1.68
	July-Aug	63	—	4.7	0.36	3.9	22.2	1.83
	Sept-Oct	63	1.3	14.0	0.89	3.0	26.4	1.63
	Nov-Dec	60	0.9	32.7	1.46	3.7	29.7	1.47
Moosonee, Canada	Jan-Feb	57	0.6	37.4	1.91	7.1	35.4	1.23
	Mar-Apr	63	—	19.3	0.95	6.4	29.5	1.13
	May-June	56	—	9.1	0.64	5.2	23.1	1.43
	July-Aug	63	0.07	5.6	0.48	4.1	22.0	1.75
	Sept-Oct	63	0.8	14.3	0.91	3.6	25.3	1.75
	Nov-Dec	63	2.2	39.8	1.73	4.7	31.6	1.68
Washington, D. C	Jan-Feb	63	1.6	42.0	2.11	6.6	36.6	1.96
	Mar-Apr	63	—	18.5	0.98	6.6	28.7	—
	May-June	56	0.6	10.1	0.61	3.7	26.1	1.68
	July-Aug	56	0.3	5.4	0.46	3.8	20.8	1.59
	Sept-Oct	63	0.3	23.7	1.01	3.9	28.2	1.74
	Nov-Dec	63	1.0	44.6	1.81	4.1	32.2	1.65
Miami, Florida	Jan-Feb	63	1.3	37.5	2.26	6.5	34.7	0.75
	Mar-Apr	63	—	19.0	1.39	5.3	26.2	1.02
	May-June	56	—	9.4	0.72	4.4	23.1	0.87
	July-Aug	63	—	7.7	0.55	3.8	25.2	1.19
	Sept-Oct	63	0.6	27.9	1.62	4.8	29.9	0.86
	Nov-Dec	63	2.5	42.7	1.92	4.2	29.8	0.99
Mauna Loa, Hawaii	Jan-Feb	63	1.4	41.2	2.03	5.3	25.6	1.63
	Mar-Apr	63	—	19.9	1.18	5.8	28.5	1.70
	May-June	56	—	12.1	0.72	4.2	24.2	1.78
	July-Aug	62	—	12.5	0.76	3.7	26.3	1.90
	Sept-Oct	60	—	22.0	1.19	4.2	22.3	1.42
	Nov-Dec	63	2.1	42.1	1.87	4.1	27.2	1.46
Miraflores, Panama Canal Zone	Jan-Feb	63	—	39.4	1.77	6.1	35.8	1.13
	Mar-Apr	63	—	18.9	1.01	6.2	29.5	1.19
	May-June	56	—	15.9	0.77	3.9	24.7	1.53
	July-Aug	62	—	10.8	0.65	5.0	28.9	1.94
	Sept-Oct	60	0.4	23.2	1.01	3.5	28.0	1.72
	Nov-Dec	63	0.9	47.3	1.73	3.2	33.5	1.50
Guayaquil, Ecuador	Jan-Feb	56	1.8	28.3	1.52	3.3	23.4	2.45
	Mar	35	0.6	18.0	1.05	3.0	21.2	2.41
	May-June[b]							
	Aug	39	1.6	29.5	1.31	3.1	41.0	2.00
	Sept-Oct	56	0.7	13.5	0.95	3.3	22.1	1.63
	Nov	21	2.5	12.0	0.93	3.3	19.8	1.80
Lima, Peru	Jan-Feb	55	0.6	3.5	1.00	1.6	4.3	2.46
	Mar-Apr	63	0.5	2.7	0.70	1.6	4.6	2.17
	May-June	63	5.0	70.1	2.40	5.8	38.1	1.74
	July-Aug	63	2.4	24.4	1.56	5.2	31.8	1.54
	Sept-Oct	56	0.6	11.8	0.92	3.8	23.7	1.43
	Nov-Dec	49	0.6	9.4	0.81	3.3	18.2	1.47
Chacaltaya, Bolivia	Jan-Feb	56	1.0	11.1	1.45	2.3	8.1	2.42
	Mar-Apr	59	0.4	—	0.69	1.6	—	—
	May-June	63	6.2	95.6	2.85	5.0	39.0	1.63
	July-Aug	42	1.7	39.6	1.45	5.1	52.3	1.44
	Sept-Oct	50	0.6	22.8	1.11	3.7	32.5	1.51
	Nov-Dec	63	0.6	12.9	0.81	3.0	22.8	1.58
Antofagasta, Chile	Jan-Feb	49	0.7	[a] 1.8	0.75	1.2	2.9	2.01
	Mar-Apr	60	0.5	[a] 1.9	0.68	1.4	3.6	2.42
	May-June	56	6.8	70.0	3.16	4.0	24.1	1.74
	July-Aug	63	1.5	22.4	1.58	4.4	29.5	1.61
	Sept-Oct	56	0.6	10.6	0.91	3.0	21.7	1.37
	Nov-Dec	63	0.5	8.3	0.75	2.9	18.7	1.58
Santiago, Chile	Jan-Feb	48	0.5	[a] 0.8	[a] 0.26	0.8	1.8	2.02
	Mar-Apr	63	—	[a] 0.4	[a] 0.33	0.8	2.0	2.37
	May-June	42	5.1	33.0	2.45	2.8	18.1	2.52
	July-Aug[b]							
	Sept-Oct	49	1.1	8.4	0.91	2.8	15.9	1.93
	Nov-Dec	56	0.8	7.1	0.71	3.3	17.8	2.09
Puerto Montt, Chile	Jan-Feb	56	0.9	[a] 3.3	[a] 0.31	0.8	1.8	1.70
	Mar-Apr	56	0.2	[a] 0.4	[a] 0.18	0.8	1.5	1.74
	May-June	63	2.7	7.6	1.88	1.3	3.9	1.49
	July-Aug	63	2.1	13.3	1.60	2.0	11.7	1.27
	Sept-Oct	56	0.8	7.1	1.01	2.8	11.6	1.17
	Nov-Dec	49	0.3	5.6	0.70	3.5	14.4	1.42
Punta Arenas, Chile	Jan-Feb	48	1.1	[a] 0.2	[a] 0.12	0.7	1.5	2.18
	Mar-Apr	63	0.2	[a] 0.2	[a] 0.19	0.7	1.5	2.41
	May-June	56	2.3	5.8	1.83	1.1	4.1	2.82
	July-Aug	63	1.5	9.2	1.39	1.9	11.4	2.50
	Sept-Oct	49	0.7	7.1	0.94	3.1	14.2	2.04
	Nov-Dec	56	0.2	6.5	0.64	2.8	13.1	2.20

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[a] Value uncertain—error exceeds 10 percent.
[b] Insufficient samples received.

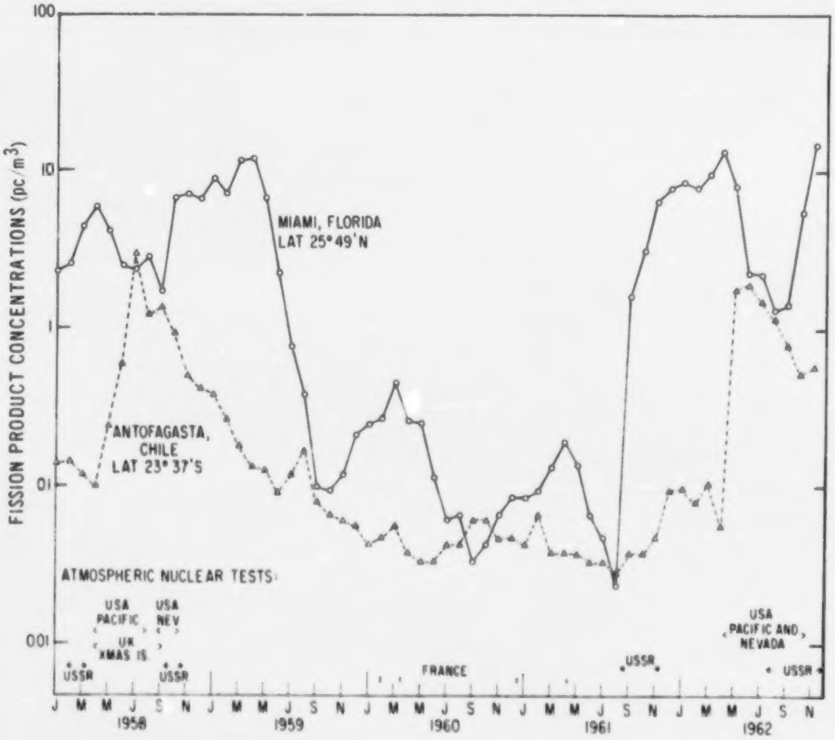

FIGURE 2.—MONTHLY AVERAGE CONCENTRATIONS OF GROSS FISSION PRODUCTS IN THE AIR AT MIAMI, FLORIDA, AND ANTOFAGASTA, CHILE, 1958–1962

Sources of Airborne Radioactivity During 1962

Consideration of the relative amounts of the different fission products in the air, particularly the Y^{91}, Ce^{144} and Sr^{90} activities, permitted approximate assignments of effective shot dates and contributions of Sr^{90} from the various sources to be made. This procedure is described in detail elsewhere (*9*).

In the Southern Hemisphere, the primary source of fission products prior to the end of April 1962 was pre-moratorium debris which had been retained in the stratosphere and slowly released. The relative contribution of Sr^{90} from the USSR 1961 tests was highest at Guayaquil (about 60%) and Chacaltaya (<20% but decreased to negligible quantities in southern Chile. The profiles of Sr^{90} assigned to the two sources during the January-February collection period are depicted in figure 4a. The suggested mechanism by which the fresher component was transferred to the Southern Hemisphere from the large source in the Northern Hemisphere is by the limited exchange of tropospheric air masses near the Equator, followed by entrainment of the transferred air in a rising cell which descended to ground level in the subtropical region of the Southern Hemisphere. The large quantity of Sr^{90} in the Northern Hemisphere is attributed primarily to the stratospheric deposition of debris from the USSR 1961 tests with about a 15 percent contribution of Sr^{90} from pre-moratorium tests.

After April 1962 a prominent contributor to radioactivity in the Southern Hemisphere was the U.S. test series at Christmas Island. As had been noted during the 1958 U.S. HARDTACK series, the fresh activity appeared in highest concentrations at Chacaltaya (elevation 5220 meters). In figure 4b the Sr^{90} profiles for the May-June period indicate the calculated contributions from each of the possible sources. No significant amounts of debris from the Christmas Island tests appeared in the Northern Hemisphere during this period.

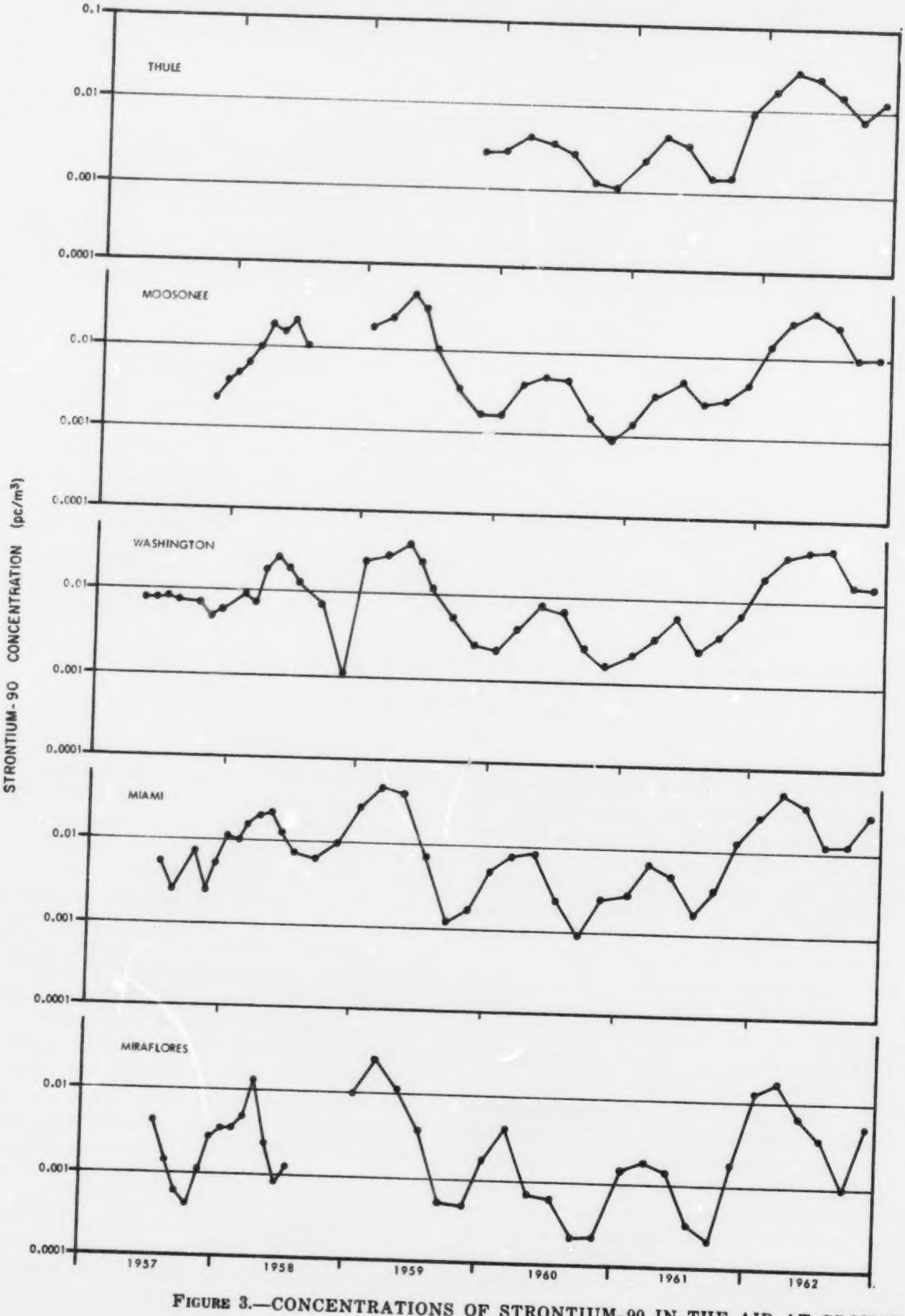

FIGURE 3.—CONCENTRATIONS OF STRONTIUM-90 IN THE AIR AT GROUND

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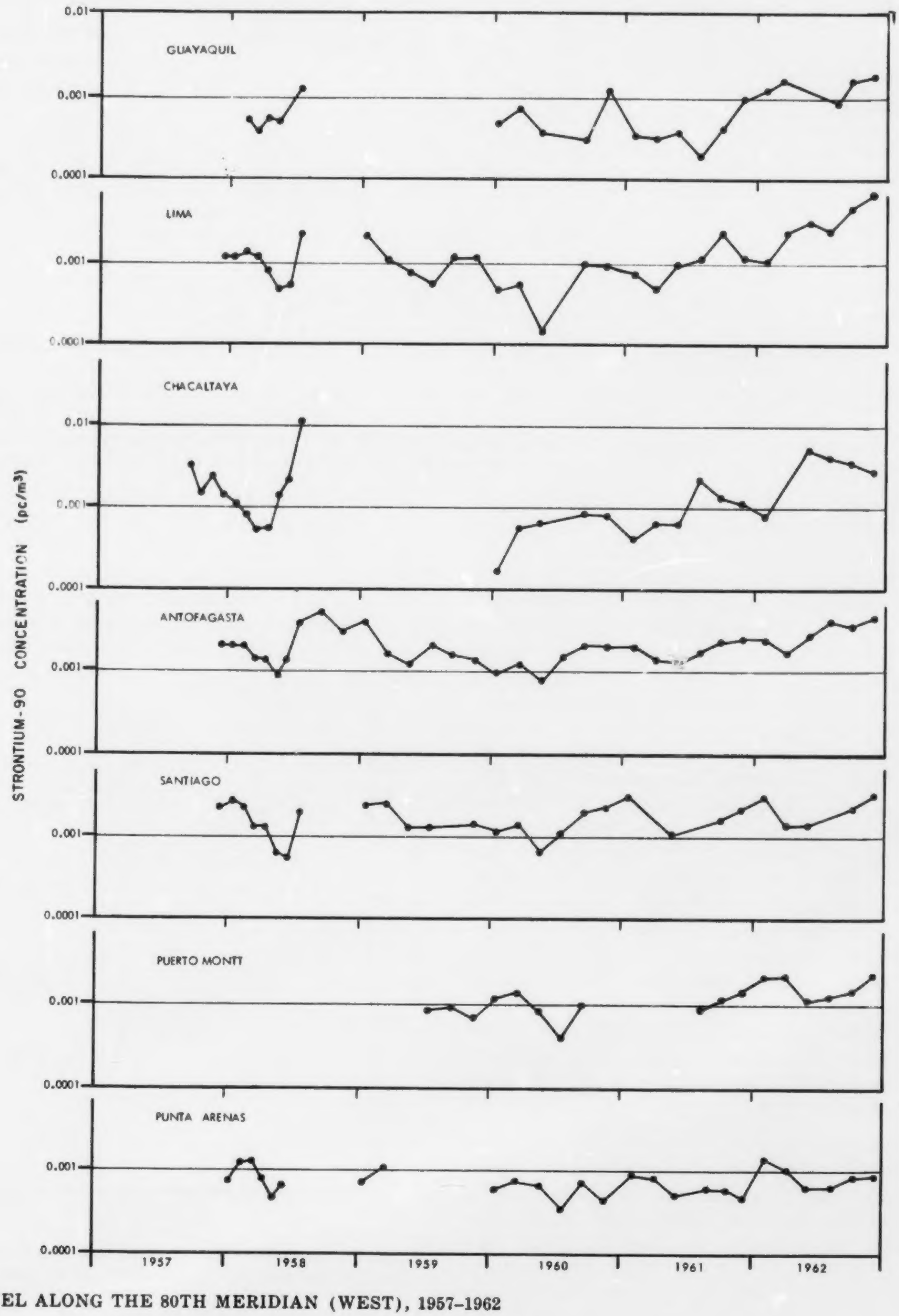

LEVEL ALONG THE 80TH MERIDIAN (WEST), 1957–1962

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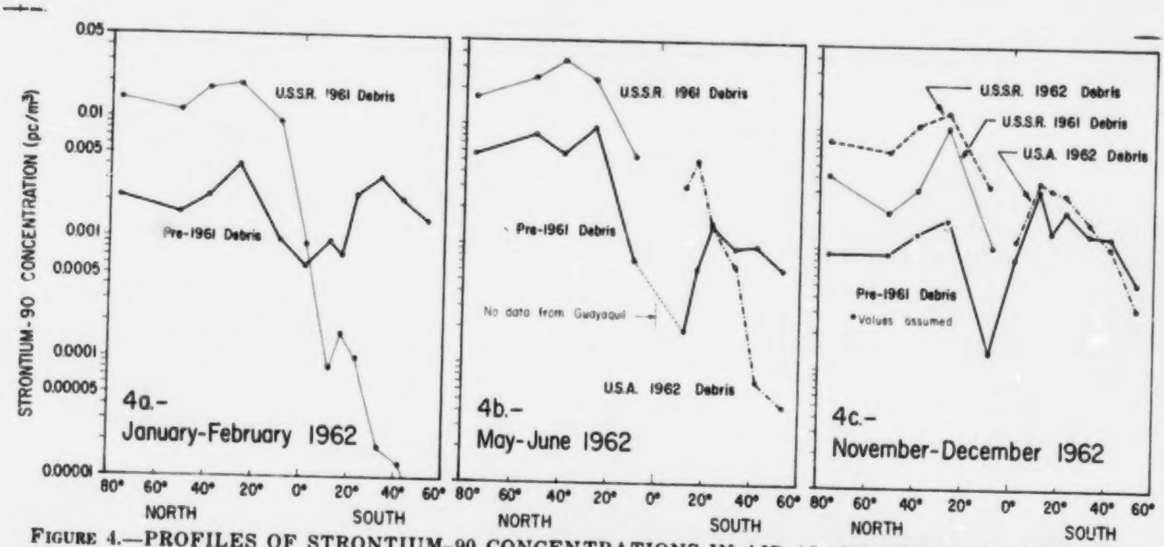

FIGURE 4.—PROFILES OF STRONTIUM-90 CONCENTRATIONS IN AIR ALONG THE 80TH MERIDIAN (WEST) DURING THREE PERIODS OF 1962 CONTRIBUTED BY VARIOUS NUCLEAR TEST SERIES

Throughout the remainder of 1962 the U.S. DOMINIC series appeared as the major source of Sr^{90} in the tropical and mid-latitudes of the Southern Hemisphere with smaller but gradually increasing contributions further south. By November-December 1962, when the Southern Hemisphere spring subsidence was bringing more stratospheric debris near the earth's surface, the old and new components were approximately equal.

The situation was more complex in the Northern Hemisphere. Though some DOMINIC debris did undoubtedly enter the Northern Hemisphere, it was not readily observable over the higher background of debris from the USSR 1961 series and, later, from the USSR 1962 series. The latitudinal profiles of Sr^{90} from the various sources for the November-December period are shown in figure 4c; here it has been assumed that the U.S. Christmas Island tests did not contribute to the Northern Hemisphere burden nor the USSR series to the Southern Hemisphere burden. An arbitrary estimate of the pre-moratorium Sr^{90} activity was also required.

Activity Ratios

The Sr^{89}/Sr^{90} activity ratios plotted in figure 5 compare the theoretical rate of change due to radioactive decay of debris from a megaton weapon detonated on October 15, 1961 (the effective mid-point of the USSR 1961 series), with measured ratios for the 80th Meridian air samples and for rainwater samples (*10, 11*) from several Northern Hemisphere sites. Scattered values during 1961 are due to mixed tropospheric and stratospheric sources of activity. The excellent agreement during early 1962, however, would indicate a common source of debris in collections made over a wide area.

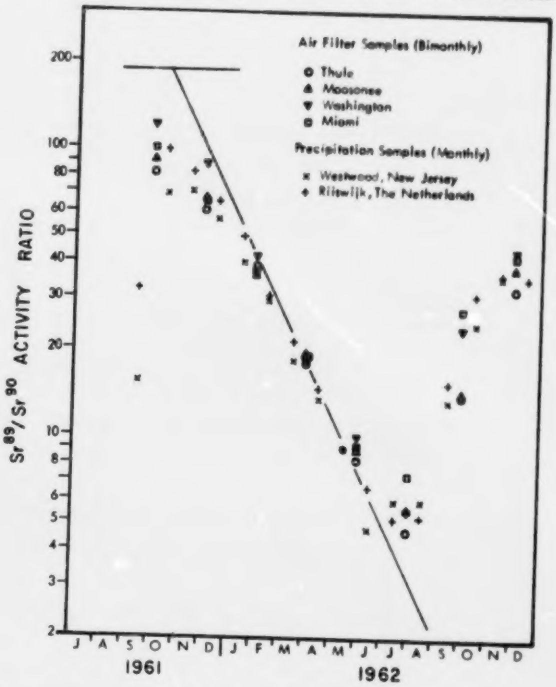

FIGURE 5.—RATIOS OF STRONTIUM-89 TO STRONTIUM-90 ACTIVITY IN THE AIR AND IN PRECIPITATION AT VARIOUS NORTHERN HEMISPHERE SITES DURING 1962

There is also evident at all sites a slowly decreasing age (increasing Sr^{89}/Sr^{90} ratio) which would suggest the gradual dilution of the source with younger debris, possibly from the extremely high yield USSR tests of October 23 and 30, 1961. Because of this, it is not possible to relate the slight increase in the Sr^{89}/Sr^{90} ratio found during May and June to the U.S. Christmas Island tests which started on April 25, 1962. However, rainfall collections made at Westwood, N.J. in May and June were reported to have contained Ba^{140} (12.8 day half-life) which indicated some contribution from the U.S. tests (*10*). The Sr^{89}/Sr^{90} activity ratio increased markedly later in the year as stratospheric deposition approached a minimum and large scale testing was resumed in the Soviet Union (August 5-December 24, 1962).

The Cs^{137}/Sr^{90} activity ratios have a rather high variability that cannot be related to any analytical difficulties and perhaps may be due to fractionation effects during transport or collection. This same pattern of variability with consistently lower than average values at Miami and Puerto Montt has been observed in past years (*7, 8*). The difficulty appears to be with the Cs^{137}, since other activity ratios involving the Sr^{90} component are as a general rule internally consistent both in space and time.

Summary

This report documents the changes in the gross beta and the Sr^{90} activity concentrations that have occurred in the air at ground level along the 80th Meridian from 1957 through 1962. The data obtained from this 80th Meridian air sampling program have contributed to our knowledge of the retention and transport of radioactivity within the atmosphere, the rather effective barrier to mixing across the Equator, and the seasonal cycles in the appearance of stratospherically-stored debris at ground level.

With the conduct of full scale testing of large yield nuclear devices in both the arctic and tropic regions during 1962, followed by what is presumed will be a more permanent moratorium on nuclear testing, the condition of the stratosphere and prospects for observations during the coming years are equivalent to those existing in the period 1959–1961. The multiplicity of sources will again cause difficulty in making quantitative interpretations of atmospheric mixing or transport processes, though there should be ample radioactivity for many other interesting studies.

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Section II—Milk and Food

MILK SURVEILLANCE

Although milk is only one of the many sources of dietary intake of radionuclides, it is the single food item most often used as an indicator of the population's intake of radionuclides from the environment. This is because fresh milk is consumed by a large segment of the United States population and contains most of the radionuclides occurring in the environment which have been identified as being biologically important. In addition, milk is produced and consumed on a regular basis, is convenient to handle, is easily analyzed, and samples which are representative of milk consumption in any area can be readily obtained.

1. Pasteurized Milk Network, February 1964

Division of Radiological Health and
Division of Environmental Engineering and
Food Protection, Public Health Service

The Public Health Service pasteurized milk radionuclide surveillance program had its origin in a raw milk network (*1*) established by the Service in 1957. One of the primary objectives of this network was the development of methods for milk collection and radiochemical analysis suitable for larger scale programs.

Experience derived from this earlier network led to the activation of a pasteurized milk sampling program with stations selected to provide nationwide surveillance of milk production and consumption areas. The present network, which consists of 63 stations, has at least one station in every State, the Canal Zone, and Puerto Rico.

Through the cooperation of State and local milk sanitation authorities, samples are routinely collected at each of these stations. Composites of the samples are preserved with formaldehyde and are sent to the PHS Southwestern (SWRHL), Southeastern (SERHL), or Northeastern Radiological Health Laboratories (NERHL) for analysis. Gamma analyses for iodine-131 are made within 3 to 6 days after sample collection, and any results exceeding 100 pc/liter are immediately telephoned to State health officials for possible public health action. Analytical results are normally available 6 to 7 weeks after collection; publication in *RHD* follows 3 to 4 months after sample collection.

Sampling and Compositing Procedures

The method specifies that each station's sample be composited of subsamples from each milk processing plant in proportion to the plant's average sales in the community served. At most stations the composited sample represents from 80 to 100 percent of the milk processed. Prior to September 15, 1961, the composite sample was taken from one day's sales per month and was as representative of the community's supply as could be achieved under practical conditions. Beginning with the resumption of nuclear weapons testing in the atmosphere in September 1961, and continuing through January 1963, samples were collected twice a week at nearly all stations and daily for short periods at selected stations. Since then, the sampling frequency has been reduced to once a week.

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Analytical Errors

Iodine–131, cesium–137, and barium–140 concentrations are determined by gamma scintillation spectroscopy.[1] After gamma scanning, samples from two consecutive weeks are composited and analyzed radiochemically for strontium–89 and strontium–90. There is an inherent statistical variation associated with all measurements of radionuclide concentrations. With the low radionuclide levels which are usually found in milk and other environmental samples this variation on a percentage basis is relatively high. The variation is dependent upon such factors as the method of chemical analysis, the sample counting rate and counting time, interferences from other radionuclides, and the background count. For milk samples, counting times of 50 minutes for gamma spectroscopy and 30 to 50 minutes for low background beta determinations are used. Table 1 shows the approximate total analytical error (including counting error) associated with radionuclide concentrations in milk. These errors were determined by comparing the results of a large number of analyses. The ± 2 standard deviations (2σ) about the measured concentration corresponds to a 95 percent certainty that the true concentration is within this range. The minimum detectable concentration is defined as the measured concentration at which the two-standard-deviation analytical error is equal to the measurement. Accordingly, the minimum detectable concentrations in units of pc/liter are Sr^{89}, 5; Sr^{90}, 2; Cs^{137}, 10; Ba^{140}, 10; and I^{131}, 10. At these levels and below the counting error comprises nearly all of the analytical error.

TABLE 1.—ANALYTICAL ERRORS ASSOCIATED WITH ESTIMATED CONCENTRATIONS FOR SELECTED RADIONUCLIDES IN MILK

Nuclide	Estimated concentration (pc/liter)	Error [a] (pc/liter)	Estimated concentration (pc/liter)	Error [a] (percent of concentration)
Iodine-131	0 to 100	±10	100 or greater	±10%
Barium-140	0 to 100	±10	100 or greater	±10%
Cesium-137	0 to 100	±10	100 or greater	±10%
Strontium-89	0 to 50	±5	50 or greater	±10%
Strontium-90	0 to 20	±2	20 or greater	±10%

[a] Two standard deviations (2σ).

Calcium analyses at SERHL are done by an ion exchange and permanganate titration method while at NERHL and SWRHL an ethylenediaminetetraacetic acid (EDTA) method is used. Stable potassium concentrations are estimated from the potassium–40 concentrations determined from the gamma spectrum (1.18×10^{-3}g K/pc K^{40}).

Data Presentation

Table 2 presents summaries of the analyses for February 1964 (January 26-February 2 1964). Although not shown in table 2, the iodine–131 and barium–140 monthly average concentrations in milk were less than 10 pc/liter. When a radionuclide is reported by a laboratory as being below the minimum detectable concentration, one-half the minimum detectable value is used as the best approximation in calculating the monthly average. Beginning with October 1963 data, however, zero is used as the best approximation to a nondetectable concentration of iodine–131 or barium–140. A similar procedure is used for the network average.

Figures 1 and 2 are isogram maps showing the estimated strontium–90 and cesium–137 concentrations in milk over the entire country. The value printed beside each station is the monthly average concentration for that station. The isograms were developed by arbitrary interpolation between values for the individual stations. Additional modifications to the isograms are made according to available information on milksheds.

In order to develop the distribution of the network's stations versus radionuclide concentrations in milk, table 3 has been prepared using monthly averages shown in table 2.

Continuing the practice followed in previous issues of *RHD*, the average monthly strontium–90 concentrations in pasteurized milk from 15 selected cities in the sampling program are presented in figure 3. Each graph shows the strontium–90 concentrations in milk from one city in each of the four U. S. Bureau of Census regions. This method of selection permits graphic presentation of data for each city in the network three times a year. The last column in table 2 shows the most recent issue in which a graph of strontium–90 concentrations was given for each station.

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[1] Southeastern Radiological Health Laboratory employs a radiochemical procedure for barium–140 analysis.

TABLE 2.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1964 [a]

[Average radioactivity concentrations in pc/liter]

Sampling locations		Calcium (g/liter)		Potassium (g/liter)		Strontium-89		Strontium-90		Cesium-137		Last Sr^{90} graph in *RHD* (1964)
		Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	Fourth quarter	Avg. for month	
Ala:	Montgomery	1.22	1.20	1.5	1.5	5	<5	21	24	85	105	June
Alaska:	Palmer	1.20	1.14	1.6	1.5	15	10	31	23	180	165	March
Ariz:	Phoenix	1.16	1.15	1.7	1.5	<5	<5	3	5	30	20	May
Ark:	Little Rock	1.20	1.22	1.5	1.6	10	<5	40	41	130	165	March
Calif:	Sacramento	1.22	1.23	1.6	1.6	<5	5	8	9	60	60	April
	San Francisco	1.22	1.21	1.6	1.6	5	5	9	13	70	75	June
Canal Zone:	Cristobal	1.13	1.14	1.5	1.6	<5	<5	5	6	40	50	March
Colo:	Denver	1.19	1.22	1.6	1.5	15	<5	17	19	85	95	April
Conn:	Hartford	1.19	1.16	1.6	1.6	10	<5	25	22	170	180	April
Del:	Wilmington	1.21	1.20	1.7	1.6	5	<5	23	19	130	150	May
D. C:	Washington	1.17	1.19	1.5	1.5	10	5	17	17	80	105	June
Fla:	Tampa	1.22	1.21	1.4	1.5	5	<5	16	16	250	190	May
Ga:	Atlanta	1.19	1.26	1.5	1.6	10	5	29	38	120	160	June
Hawaii:	Honolulu	1.15	1.20	1.7	1.6	10	<5	11	12	85	75	March
Idaho:	Idaho Falls	1.19	1.15	1.6	1.6	15	<5	26	39	170	240	May
Ill:	Chicago	1.18	1.18	1.7	1.6	10	<5	20	21	110	145	June
Ind:	Indianapolis	1.25	1.23	1.6	1.5	10	<5	22	24	100	115	April
Iowa:	Des Moines	1.18	1.20	1.5	1.5	15	<5	25	27	100	105	May
Kans:	Wichita	1.16	1.24	1.6	1.6	10	<5	18	24	65	80	March
Ky:	Louisville	1.16	1.20	1.5	1.6	15	<5	30	31	100	125	May
La:	New Orleans	1.24	1.22	1.5	1.5	15	5	44	49	135	155	March
Maine:	Portland	1.22	1.17	1.6	1.6	10	<5	35	32	235	215	May
Md:	Baltimore	1.14	1.19	1.4	1.5	10	<5	20	20	105	115	May
Mass:	Boston	1.22	1.20	1.6	1.6	15	<5	36	34	250	255	June
Mich:	Detroit	1.20	1.20	1.6	1.5	5	<5	20	19	120	130	April
	Grand Rapids	1.23	1.20	1.6	1.5	5	<5	22	23	130	140	May
Minn:	Minneapolis	1.18	1.16	1.6	1.6	25	5	33	38	155	190	June
Miss:	Jackson	1.25	1.26	1.4	1.5	15	10	36	38	105	125	April
Mo:	Kansas City	1.17	1.18	1.5	1.5	15	10	29	29	85	100	April
	St. Louis	1.20	1.18	1.6	1.5	15	<5	21	23	85	95	March
Mont:	Helena	1.20	1.18	1.6	1.5	10	<5	29	33	195	230	March
Nebr:	Omaha	1.20	1.18	1.6	1.6	25	5	25	26	95	105	May
Nev:	Las Vegas	1.14	1.21	1.7	1.5	<5	<5	10	14	80	85	June
N. H:	Manchester	1.24	1.19	1.6	1.7	10	<5	37	34	275	260	May
N. J:	Trenton	1.20	1.19	1.6	1.5	10	<5	19	17	120	135	April
N. Mex:	Albuquerque	1.16	1.18	1.6	1.5	<3	<5	11	14	50	55	March
N. Y:	Buffalo	1.18	1.16	1.7	1.6	10	<5	23	20	145	175	April
	New York	1.20	1.16	1.7	1.6	15	<5	30	26	175	185	June
	Syracuse	1.19	1.19	1.7	1.7	10	5	22	22	150	165	March
N. C:	Charlotte	1.19	1.25	1.5	1.5	15	5	30	28	105	115	March
N. Dak:	Minot	1.18	1.20	1.6	1.5	40	10	55	67	145	165	May
Ohio:	Cincinnati	1.23	1.22	1.6	1.5	10	<5	23	24	90	125	April
	Cleveland	1.22	1.21	1.7	1.6	5	<5	22	20	105	125	March
Okla:	Oklahoma City	1.17	1.21	1.5	1.6	5	<5	21	27	70	90	June
Ore:	Portland	1.21	1.22	1.6	1.5	20	5	30	26	180	145	April
Pa:	Philadelphia	1.22	1.19	1.6	1.6	5	<5	21	19	120	140	March
	Pittsburgh	1.27	1.[illegible]	1.6	1.6	10	<5	29	27	145	170	March
P. R:	San Juan	1.16	1.17	1.5	1.6	5	<5	12	12	65	70	March
R. I:	Providence	1.21	1.18	1.6	1.6	5	<5	27	24	175	190	May
S. C:	Charleston	1.21	1.21	1.5	1.5	10	<5	27	36	120	150	April
S. Dak:	Rapid City	1.20	1.15	1.7	1.5	25	5	42	45	170	170	June
Tenn:	Chattanooga	1.23	1.22	1.5	1.5	15	5	35	35	120	145	June
	Memphis	1.22	1.23	1.5	1.5	10	<5	28	32	75	80	May
Tex:	Austin	1.18	1.20	1.5	1.6	<5	<5	8	11	40	55	June
	Dallas	1.20	1.21	1.5	1.6	5	<5	19	21	75	90	April
Utah:	Salt Lake City	1.19	1.22	1.6	1.5	15	5	26	28	170	210	March
Vt:	Burlington	1.21	1.17	1.6	1.6	10	<5	28	28	200	205	April
Va:	Norfolk	1.17	1.19	1.5	1.5	10	<5	21	19	90	105	April
Wash:	Seattle	1.21	1.20	1.6	1.5	15	10	24	20	155	115	June
	Spokane	1.21	1.22	1.7	1.6	20	5	31	35	160	145	April
W. Va:	Charleston	1.17	1.22	1.4	1.5	15	<5	26	26	85	110	June
Wis:	Milwaukee	1.28	1.22	1.8	1.7	<5	<5	19	19	135	155	May
Wyo:	Laramie	1.18	1.11	1.6	1.5	15	5	20	24	115	105	May
Network average		1.20	1.20	1.6	1.6	11	<5	24.2	25.3	123	135	Nov. 63

[a] The monthly average iodine-131 and barium-140 concentration at each station was <10 pc/liter.

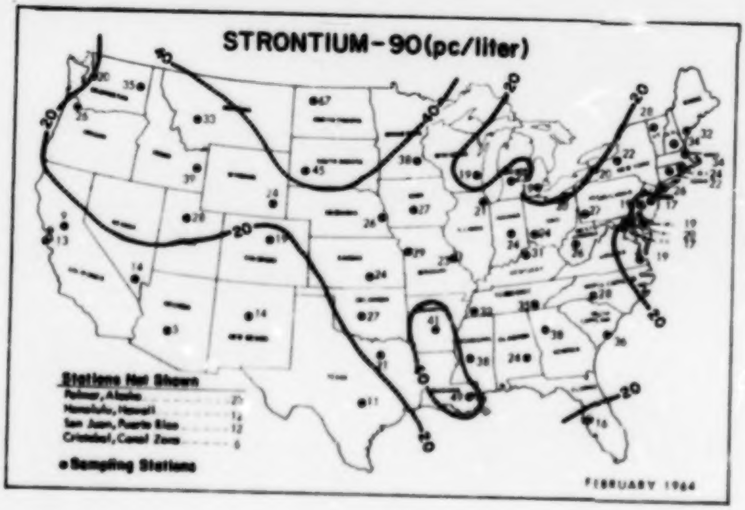
STRONTIUM-90(pc/liter)
Stations Not Shown
Palmer, Alaska 20
Honolulu, Hawaii 14
San Juan, Puerto Rico 12
Cristobal, Canal Zone 6
Sampling Stations
FEBRUARY 1964

FIGURE 1.—STRONTIUM-90 CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1964

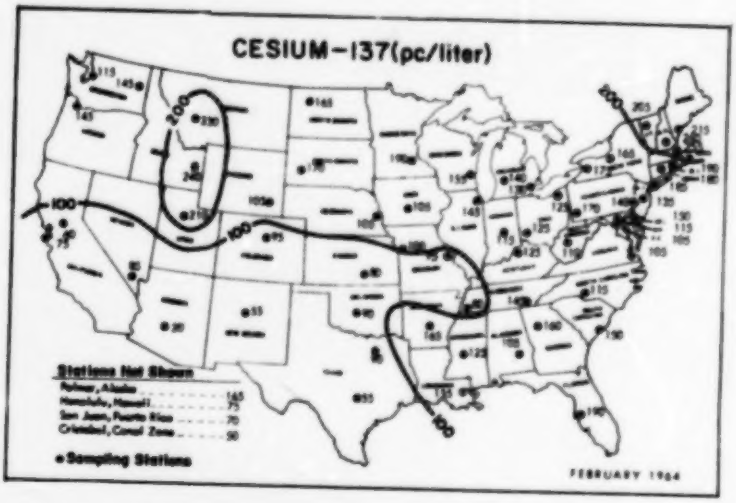
CESIUM-137(pc/liter)
Stations Not Shown
Palmer, Alaska 165
Honolulu, Hawaii 75
San Juan, Puerto Rico 70
Cristobal, Canal Zone 50
Sampling Stations
FEBRUARY 1964

FIGURE 2.—CESIUM-137 CONCENTRATIONS IN PASTEURIZED MILK, FEBRUARY 1964

TABLE 3.—DISTRIBUTION OF SAMPLING STATIONS IN VARIOUS RANGES OF RADIONUCLIDE CONCENTRATIONS IN MILK, FEBRUARY 1964

Strontium-89		Strontium-90		Iodine-131		Cesium-137		Barium-140	
Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations	Range (pc/liter)	Number of stations
<5	43	<1-9	3	<10	63	<5-45	1	<10	63
5	15	10-14	6			50-95	14		
10	5	15-19	9			100-145	24		
		20-24	17			150-195	17		
		25-29	11			200-245	5		
		30-34	6			250-295	2		
		35-39	7						
		40-69	4						
Total	63	Total	63	Total	63	Total	63	Total	63

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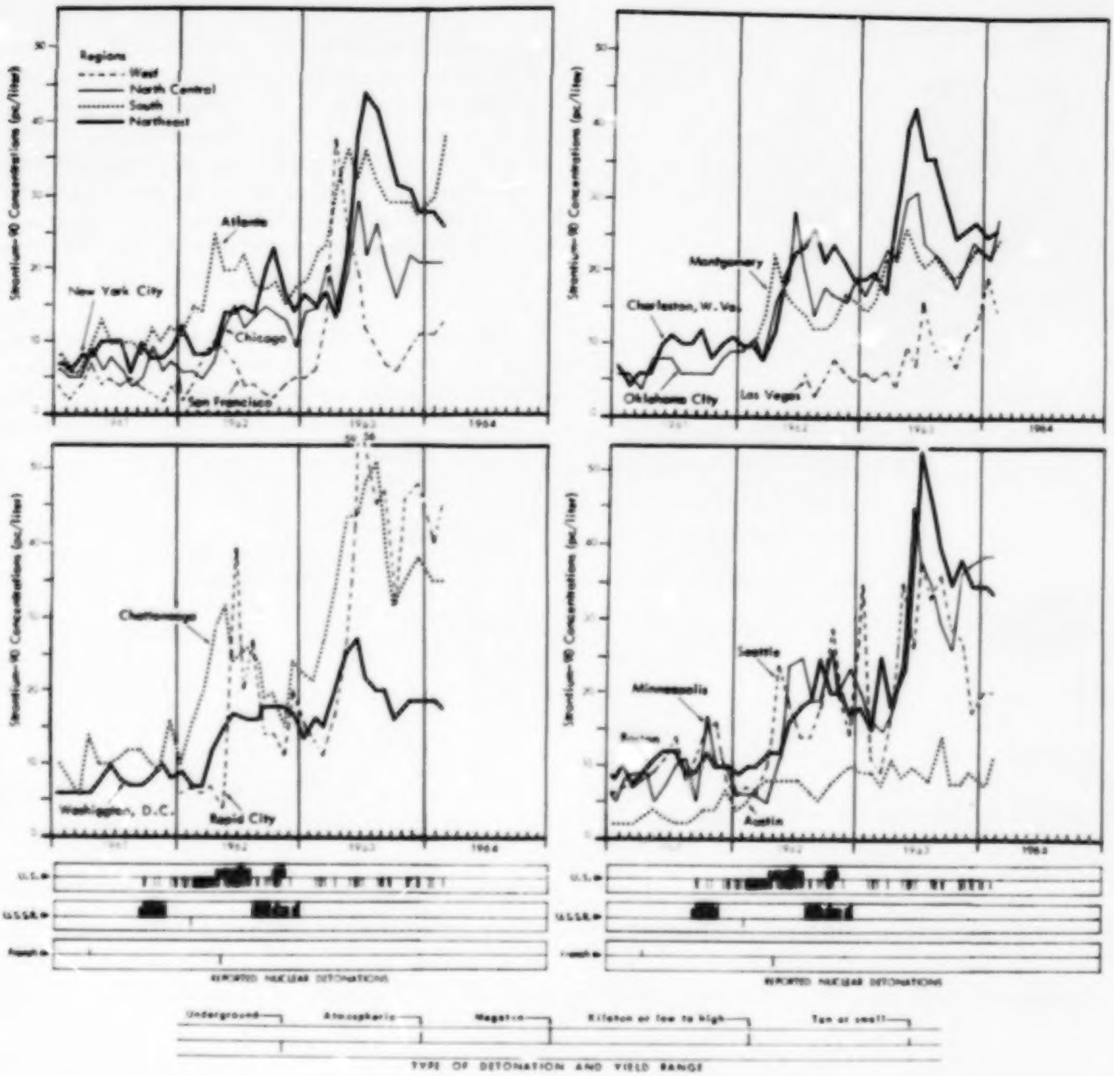

FIGURE 3.—STRONTIUM-90 IN PASTEURIZED MILK, 1961—FEBRUARY 1964

2. California Milk Network,[2] October-December 1963

State of California
Department of Public Health

Surveillance of specific radionuclides in milk is one phase of California's Department of Public Health program of radiation control. This milk monitoring function has been conducted at 8 milksheds since January 1960 by the Department's Bureau of Radiological Health, a constituent of the Division of Environmental Sanitation. Since the addition of the Del Norte and Mendocino milksheds to the program in March 1962, sampling of pasteurized milk weekly or biweekly has been conducted at 10 major milksheds (see figure 4). The original sampling locations were chosen by the State Department of Agriculture as being representative of milk consumed by a high percentage of the population of the State.

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[2] Data from *Radiological Health News* Vol. 3, No. 2, Bureau of Radiological Health, State of California Department of Public Health, 2151 Berkeley Way, Berkeley 4, California.

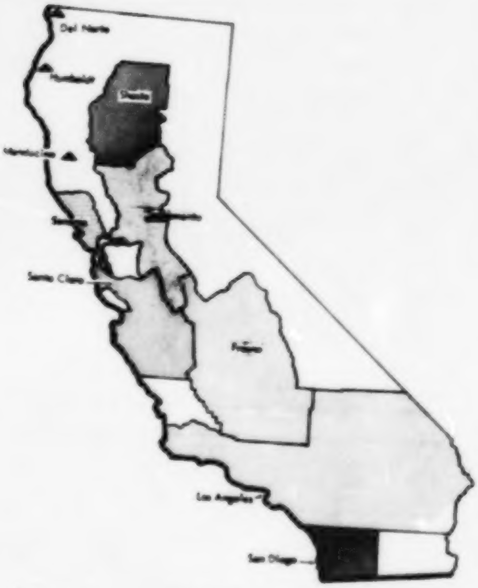

FIGURE 4.—CALIFORNIA MILKSHEDS

Methodology

Radiostrontium is determined by beta counting of strontium (yttrium) isolated from the filtrate obtained after precipitation of the proteins with trichloroacetic acid. The beta counting is done in a low background counter, usually for a 60-minute period.

Potassium-40, iodine-131, cesium-137, and barium-140 in whole fluid milk are determined by gamma scintillation spectroscopy using a sodium-iodide crystal. A normal counting time of 100 minutes is used. The stable potassium content of milk (g/liter) may be estimated by multiplying the potassium-40 concentration (pc/liter) by 1.18 x 10^{-3}. A more complete description of the laboratory equipment and procedures has been published in the February 1963 issue of *Radiological Health Data* (2).

Results

The monthly averages of the radionuclide and calcium data for milk for the period October-December 1963 are presented in table 4. The

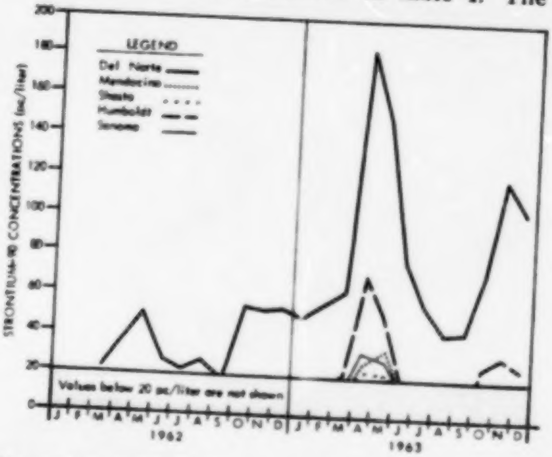

FIGURE 5.—MONTHLY AVERAGE STRONTIUM-90 CONCENTRATIONS IN MILK FROM ALL CALIFORNIA MILKSHEDS

TABLE 4.—STABLE ELEMENT AND RADIONUCLIDE CONCENTRATIONS IN CALIFORNIA MILK, OCTOBER-DECEMBER 1963 [a]

[Radioactivity concentrations in pc/liter]

Element and month	Del Norte	Fresno	Humboldt	Los Angeles	Mendocino	Sacramento	San Diego	Santa Clara	Shasta	Sonoma	Average
Calcium (g/liter)											
October	1.33	1.15	1.19	1.11	1.19	1.17	1.18	1.16	1.14	1.23	1.19
November	1.33	1.16	1.22	1.13	1.18	1.22	1.14	1.17	1.21	1.24	1.20
December	1.34	1.25	1.17	1.16	1.23	1.26	1.20	1.20	1.31	1.30	1.24
Potassium-40											
October	1140	1190	1150	1200	1220	1200	1230	1180	1200	1220	1190
November	1210	1180	1220	1270	1340	1290	1300	1290	1180	1300	1260
December	1150	1280	1200	1270	1280	1260	1300	1230	1280	1260	1250
Strontium-89											
October	33	4	27	3	5	6	2	2	4	7	14
November	102	5	29	3	8	8	3	4	9	6	18
December	28	3	16	4	5	4	2	4	9	7	8
Strontium-90											
October	73	4	27	4	6	6	3	3	5	6	14
November	121	6	33	7	10	8	5	5	12	11	22
December	104	6	27	5	9	6	4	9	14	9	19
Cesium-137											
October	277	41	111	49	47	41	27	44	55	49	74
November	467	64	165	59	54	70	54	57	84	73	115
December	339	60	104	57	61	59	53	97	114	81	103

[a] All values tabulated are at least twice the counting error at the 95 percent confidence level. The monthly iodine-131 and barium-140 averages at all stations during this period were zero.

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monthly average concentrations of strontium-90 in milk for 1962–63 are shown in figure 5. Background information on the differences among the California milksheds were discussed by Heslep and Cornish in the December 1963 issue of *Radiological Health Data* (*3*).

3. Indiana Milk Network, February 1964

Bureau of Environmental Sanitation
Indiana State Board of Health

The Indiana State Board of Health began sampling pasteurized milk for radiological analysis in September 1961. Indiana was geographically divided into five major milksheds, and one large dairy within each milkshed was selected as a sampling station (see figure 6).

The milk samples are routinely analyzed for iodine–131, cesium–137, barium–140, strontium–89 and strontium–90. Until August 1963, analyses for the gamma emitters iodine–131, cesium–137 and barium–140 were conducted on a weekly basis, except when iodine–131 exceeded 100 pc/liter, at which times the frequency of sampling was increased. Because of continued low concentrations of the short-lived gamma emitters, the sampling frequency was reduced in August 1963 to once per month for the northeast, southeast and southwest milksheds. Strontium–89 and strontium–90 analyses are performed monthly for each station.

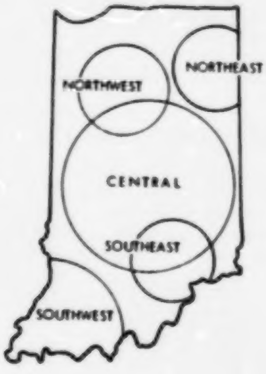


FIGURE 6.—INDIANA MILK SAMPLING LOCATIONS

An ion exchange analytical procedure (*4*) is employed for strontium–89 and strontium–90 analyses. A 512-channel pulse height analyzer and shielded 4 x 4-inch sodium iodide crystal are used for the gamma analysis of iodine–131, cesium–137, and barium–140.

The monthly averages of the data obtained for the individual sampling stations and the State averages are reported in table 5. The State average is an arithmetic average of the station values.

TABLE 5.—CALCIUM AND RADIONUCLIDES IN INDIANA MILK, FEBRUARY 1964 [a]

[Radionuclide concentrations in pc/liter]

Sampling location	Calcium (g/liter)	K^{40}	Sr^{89}	Sr^{90}	Cs^{137}	Ba^{140}
Northeast	1.10	1260	0	13	115	0
Southeast	1.14	1280	0	21	120	0
Central	1.15	1280	0	14	115	0
Southwest	1.14	1200	0	15	110	10
Northwest	1.15	1310	5	15	125	0
State average	1.14	1270	0	16	115	0

[a] The monthly average iodine-131 concentration at each station was zero.

4. Minnesota Milk Network, July-December 1963

Division of Environmental Sanitation
Minnesota Department of Health

In September 1958, the Minnesota Department of Health initiated a surveillance network to monitor pasteurized milk for strontium–90. Through October 1962, the network operators collected daily two-ounce milk samples that were composited together for monthly strontium–90 analyses. Beginning in October 1961, weekly one-liter grab samples were also collected for iodine–131 analyses. Then, beginning in November 1962, a portion of each weekly sample was retained for monthly strontium–90 analyses.

In August 1963, the network began sampling for iodine–131, cesium–137 and strontium–90 analyses on the monthly sampling basis which is now in effect. At present the network consists of eight milksheds bounded by the same lines as the Minnesota health districts. One-liter samples of processed Grade A fluid milk samples are collected at bottling machines in the pasteurized plants so that samples are gen-

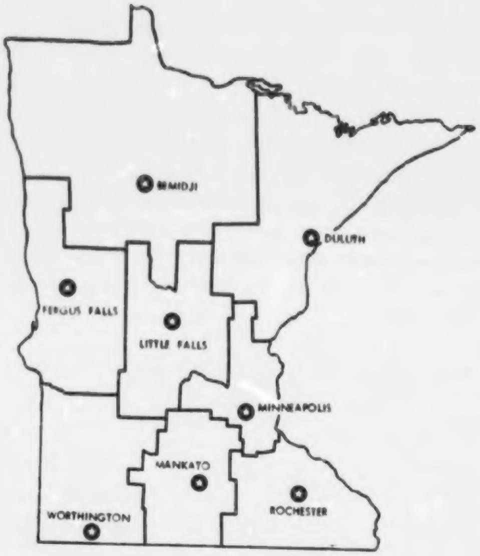


FIGURE 7.—MINNESOTA MILK SAMPLING LOCATIONS

erally representative of the milk produced in each milkshed. These samples are usually collected in the cities where the Minnesota Health District Office is located. It is sometimes convenient to collect a sample in a district at a location other than that in which the district office is situated. This type of sample is considered as representative of the district as a sample collected in the vicinity of the district office.

Analytical Procedure

Strontium–90 in milk is determined after ashing (450°C) the evaporated residue from an 800-ml sample. Evaporation is accomplished by means of a steam bath and infrared overhead heating. Calcium and strontium are precipitated as oxalates at a pH of 4 from a nitric acid solution of the ash. The separated oxalates are then decomposed with nitric acid and peroxide and the resulting solution scavenged with yttrium and barium (as chromate) in the presence of ammonium chloride. Yttrium–90 is allowed to ingrow in the presence of stable yttrium carrier and then precipitated under the same conditions prevailing in the scavenging procedure. The yttrium precipitate is converted to the oxalate, filtered and counted in a low-background anticoincidence counter.

Iodine–131 and cesium–137 are determined by gamma spectrometry. One-liter samples of milk are counted for 100 minutes with a low-background sodium iodide crystal scintillator and multichannel analyzer. Either a 3 x 3-inch crystal and 256-channel analyzer or a 4 x 4-inch crystal and 512-channel analyzer is used. The counts in the iodine–131 photopeak which occur because of background and scatter from other gamma-emitting nuclides in milk are subtracted from the total. The value to be subtracted is empirically determined, and is based on the slope of the spectrum in this area and the magnitude of the counts in the channels adjacent to the photopeak. The minimum detectable concentration of iodine–131 in milk is 10 pc/liter.

Results

The monthly strontium–90, iodine–131, and cesium–137 concentrations in milk are given in table 6. These data as well as analytical procedures are presented in the semiannual report of the Minnesota Department of Health and Rural Cooperative Power Association (*5*).

Recent coverage in *Radiological Health Data:*

Period	*Issue*
October-December 1961 (iodine–131 data)	*March 1962*
May-December 1961 (strontium–90 data)	*August 1962*
March-September 1962	*April 1963*
September 1962-June 1963	*November 1963*

TABLE 6.—RADIONUCLIDES IN MINNESOTA MILK, JULY-DECEMBER 1963 [a]

[Concentrations in pc/liter]

Sampling location (District office)	Strontium-90						Cesium-137					
	July	August	September	October	November	December	July	August	September	October	November	December
Bemidji	49	64	63	49	31	46	344	435	420	310	270	310
Duluth	54	38	48	43	40	47	378	410	340	[b] —	360	340
Fergus Falls	42	40	33	49	30	30	214	265	230	240	210	260
Little Falls	56	35	29	19	22	—	394	270	235	240	—	330
Mankato	28	26	19	20	19	22	184	200	170	—	180	190
Minneapolis	51	33	23	20	28	35	238	265	195	215	210	275
Rochester	29	30	25	28	38	25	186	210	160	—	190	220
Worthington	40	26	27	16	20	23	174	140	—	140	145	150
Average	43.6	36.5	33.4	30.5	28.5	32.6	245	275	253	226	224	249

[a] Each monthly iodine-131 concentration at each station was <10 pc/liter during July-December 1963.
[b] A dash indicates no sample.

5. New York Milk Network, October-December 1963

Division of Environmental Health Services, State of New York Department of Health

Milk samples, collected routinely from six cities—Albany, Buffalo, Massena, Newburgh, New York City, and Syracuse (figure 8)—are analyzed for their radionuclide content by the State of New York Department of Health. Pasteurized milk samples are collected daily and composited weekly for the determination of strontium-89, strontium-90, iodine-131, cesium-137 and barium-140-lanthanum-140 at all stations except Massena, where samples are composited bi-weekly and at New York City where one daily milk sample representing the total milk supply for that day is obtained and analyzed once a week. Samples are obtained from processing plants except at Albany, where the daily sample is obtained from a marketing point. During periods when cows are no longer on stored feed, the sample from Albany is analyzed daily for iodine-131. In the event that any city reports iodine-131 concentrations exceeding 100 pc/liter, increased surveillance is undertaken.

A matrix method (*6*) is used for the analysis of spectral data to determine the concentrations of gamma-emitting nuclides in milk. With this method, the individual nuclide contributions to the gamma spectrum are separated by solution of simultaneous equations describing the spectral interferences.

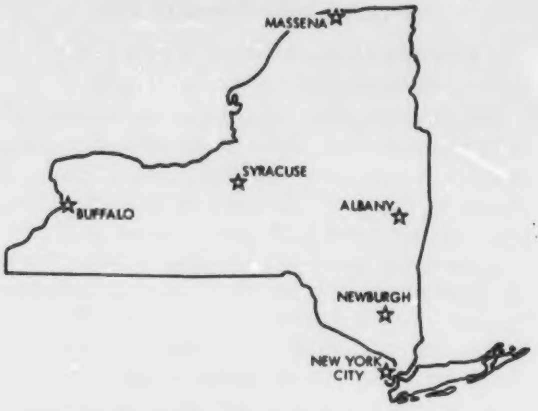


FIGURE 8.—NEW YORK MILK SAMPLING LOCATIONS

The analytical procedure for strontium-89 and strontium-90 is based on ion exchange methods. Cations (including radiostrontium) are eluted from the ion exchange resin with sodium chloride solution; strontium isotopes are gathered by means of sodium carbonate, isolated by means of ethylenediaminetetraacetic acid (EDTA), and radiostrontium is counted with a low background beta counter having an 0.8 mg/cm² window. The strontium-90 portion is differentially estimated by a second count 40 hours later to determine the rate of growth of its daughter product yttrium-90. The monthly average radionuclide concentrations in milk are shown in table 7.

TABLE 7.—RADIONUCLIDES IN NEW YORK MILK, OCTOBER-DECEMBER 1963 [a]

[Average concentrations in pc/liter]

Sampling location	Strontium-89			Strontium-90			Cesium-137		
	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.	Oct.	Nov.	Dec.
Albany	20	13	8	21	21	18	101	110	120
Buffalo	24	8	12	14	14	13	79	102	102
Massena	16	10	4	31	28	28	160	221	194
Newburgh	19	7	12	20	21	21	92	98	121
New York City	20	19	8	25	24	25	117	122	153
Syracuse	17	20	7	20	27	20	87	96	126
Average	19	13	9	22	23	21	106	125	134

[a] The monthly average I^{131} and $Ba\text{-}La^{140}$ at each station was <20 pc/liter.
Note: $Ba\text{-}La^{140}$ refers to the sum of these two nuclides in equilibrium.

6. Oregon Milk Network, November 1963-February 1964

Division of Sanitation & Engineering, Oregon State Board of Health

The Oregon State Board of Health conducts milk monitoring at eight major milk-producing centers throughout the State of Oregon, as shown in figure 9. Half-gallon samples of pasteurized packaged milk are collected Statewide on a monthly basis by the Oregon Department of Agriculture and weekly in the Portland area by the city of Portland. Milk sampling frequency is accelerated to a weekly schedule at those locations having radionuclide concentrations in milk in excess of 100 pc/liter for iodine-131 or 500 pc/liter for cesium-137 (suggestive of elevated strontium-90 concentrations). The samples are forwarded to the Oregon State Board of Health radiation laboratory for iodine-131, cesium-137, barium-140, and strontium-90 analyses. Gamma analyses are performed utilizing a 3" x 3" sodium iodide scintillation detector with a 512-channel gamma spectrometer system. Samples are normally counted for 100 minutes. The strontium-90 concentrations reported by the Oregon State Board of Health were analyzed using the trichloracetic acid analytical procedure (7) with the counting performed using a low background beta proportional counter. The minimum detectable concentrations for iodine-131, cesium-137, and barium-140 are 15 pc/liter. The minimum detectable concentration is defined to be that amount of activity which, in the same counting time, will exceed the background by 3σ (counting error) of the background.

Table 8 presents the Oregon milk surveillance data for the period November 1963 through February 1964. Figure 10 shows iodine-131, cesium-137, and strontium-90 concentrations

Table 8.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK, NOVEMBER 1963—FEBRUARY 1964 [a]

[Average concentrations in pc/liter]

Sampling location & frequency	Nuclide	November	December	January	February
Baker (monthly)	Sr^{90}	[b] —	—	—	26
	Cs^{137}	110	115	175	195
Coos Bay (monthly)	Sr^{90}	—	—	—	31
	Cs^{137}	315	255	190	240
Eugene (monthly)	Sr^{90}	—	—	—	19
	Cs^{137}	130	125	159	125
Medford (monthly)	Sr^{90}	—	—	—	13
	Cs^{137}	65	145	160	180
Nyssa (monthly)	Sr^{90}	—	—	—	13
	Cs^{137}	95	130	110	120
Portland Composite (weekly)	Sr^{90}	[c] 36	[c] 26	—	[d] 21
	Cs^{137}	190	165	175	130
Portland Local Producer (weekly)	Sr^{90}	—	—	—	[d] 25
	Cs^{137}	175	170	170	155
Redmond (monthly)	Sr^{90}	—	—	—	14
	Cs^{137}	110	115	155	155
Tillamook (weekly)	Sr^{90}	—	—	—	[d] 17
	Cs^{137}	380	340	200	160

[a] Iodine-131 and barium-140 concentrations were below lower limit of detection of 15 pc/liter. Unidentified radionuclides with a half-life of about 5 days interfered with some iodine-131 analyses.

[b] No analysis performed.

[c] Analysis by U.S. Public Health Service. All other analyses by Oregon State Board of Health.

[d] Monthly analysis.

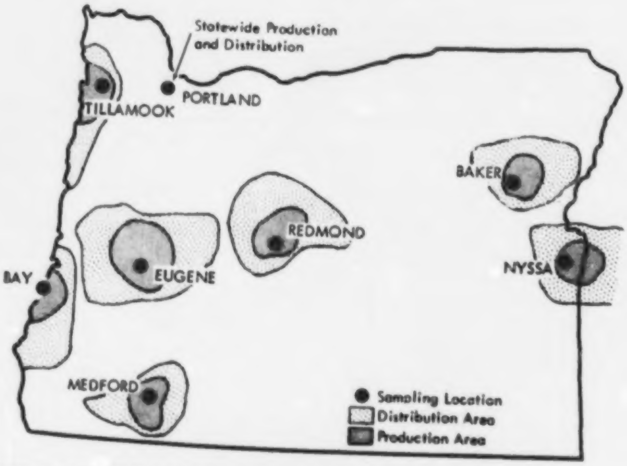
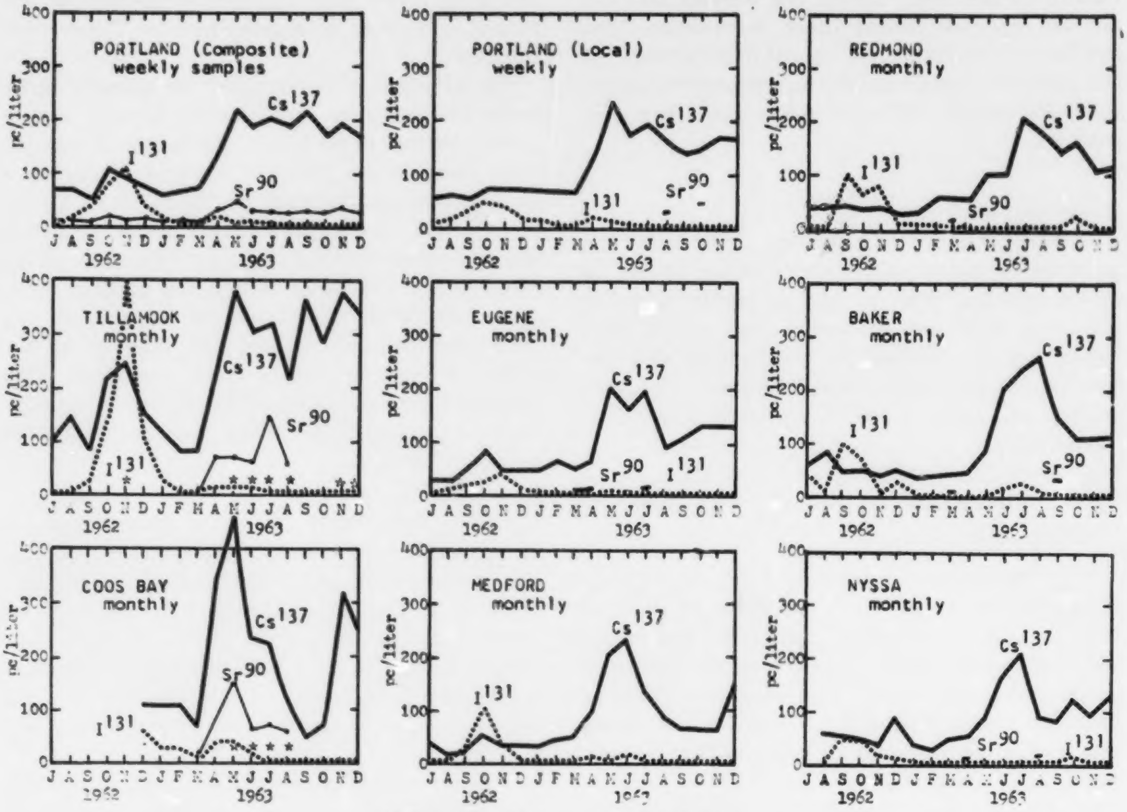


FIGURE 9.—OREGON PASTEURIZED MILK NETWORK SAMPLING LOCATIONS SHOWING PRODUCTION AND DISTRIBUTION AREAS

for all sampling locations. The Portland composite sample represents contributions from nearly all milksheds in Oregon, plus some in Southern Washington. Thus, it tends to represent a State average.

Previous coverage in *Radiological Health Data*

Period	Issue
November 1962-February 1963	*May 1963*
March-June 1963	*September 1963*
July-October 1963	*February 1964*



(* Sampling done on a weekly basis)

FIGURE 10.—RADIONUCLIDE CONCENTRATIONS IN OREGON MILK SAMPLES

7. Canadian Milk Network,[3] February 1964

Radiation Protection Division,
Department of National Health and Welfare

The Radiation Protection Division of the Department of National Health and Welfare began monitoring milk for strontium-90 in November 1955. At first, analyses were carried out on samples of powdered milk obtained from processing plants. However, since January 1963, liquid whole milk has been analyzed instead. With this change, more representative samples of milk consumed can be obtained, and in addition it is possible to choose milk sampling locations (see figure 11) in the same areas as the air and precipitation stations. At present, the analyses include determinations of iodine-131, strontium-89, cesium-137 and strontium-90 as well as stable potassium and calcium.

The milk samples are obtained through the cooperation of the Marketing Division of the Canadian Department of Agriculture. At each station samples are collected three times a week from selected dairies, combined into weekly composites, and forwarded to the radiochemical laboratory in Ottawa. The contribution of each dairy to the composite sample is directly proportional to its volume of sales. In most cases a complete sample represents over 80 percent of the milk processed and distributed in the area. Several of the weekly samples are randomly selected and analyzed for iodine-131. The results of the spot checks for iodine-131 will not be reported unless there is evidence that the levels are rising. A monthly composite of the samples is analyzed for strontium-90, strontium-89, cesium-137, and stable potassium and calcium.

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[3] Data from *Radiation Protection Programs, Vol. 2, No. 3*:25-30, Radiation Protection Division, Canadian Department of National Health and Welfare, Ottawa, Canada (March 1964).

Analytical Methods

Radiochemical methods are used for the analysis of iodine-131 (*8*). Carrier iodine is added and the milk is then evaporated in the presence of sodium hydroxide and ashed. The iodide ion is oxidized to free iodine and extracted with carbon tetrachloride, back-extracted in sulfite solution, and precipitated as silver iodide. The precipitate is counted in a low background beta counter and the iodine-131 determined by comparison with standard preparations.

For the analysis of radiostrontium, carrier strontium is added to a one-liter sample of milk, and the milk is then placed in a tray lined with a polyethylene sheet, and evaporated under infra-red lamps. The residue is ashed in a muffle furnace at 450° C, dissolved in dilute nitric acid, and strontium separated by fuming nitric acid precipitation. The combined strontium-89 and strontium-90 are determined by counting in a low background beta counter. Strontium-90 is determined separately by extracting and counting the yttrium-90 daughter nuclide while strontium-89 is estimated by difference from the total radiostrontium measurement. Appropriate corrections are made for self-absorption and counter efficiency at all stages. Calcium is determined by flame photometry.

Cesium-137 is determined by gamma spectroscopy using a scintillation crystal and a multi-channel pulse height analyzer. A sample consisting of 4.5 liters of milk is placed in a sample tray constructed in the form of an inverted well to accommodate the 5 x 4-inch sodium iodide crystal detector. The sample is counted for 100 minutes and the gamma spectrum recorded. Estimates are made of the potassium-40 and cesium-137 content of the milk by comparison of the spectrum with standard preparations. The stable potassium content is estimated from the potassium-40 concentration.

Sources of Error

In the iodine and strontium determinations, tests indicate that the statistical error (95 percent confidence level) in the chemical operations involved is about plus-or-minus 10 percent. This value is independent of the concentration of the radio isotope in the milk because it depends only on the recovery of the carrier. In the determination of cesium-137 this factor is not involved.

The chemical procedures error must be combined with the counting error which depends primarily on the concentration of the nuclide

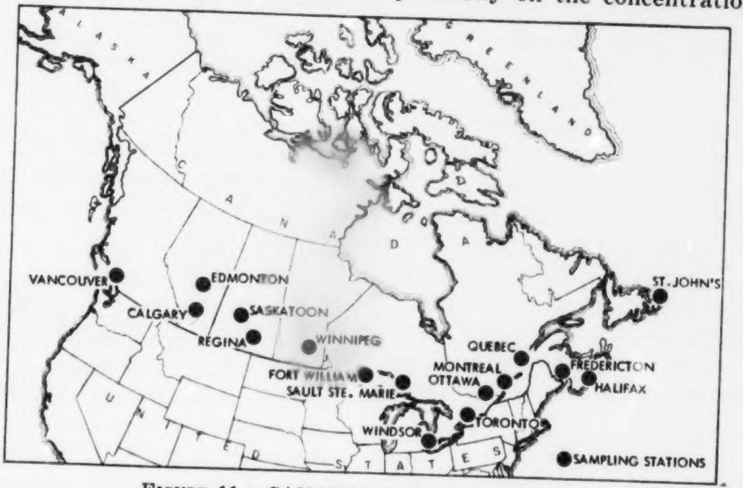

FIGURE 11.—CANADIAN MILK SAMPLING STATIONS

in the sample, the background radiation, and the length of time the sample and background are counted. This counting error has been evaluated mathematically for the particular counting arrangement used.

The overall errors, estimated on the basis indicated above, are given in table 9.

TABLE 9.—TOTAL ERROR FOR VARIOUS RADIONUCLIDE CONCENTRATIONS IN MILK[a]

Nuclide	Error for 10 pc/liter	Error for 50 pc/liter	Error for 100 pc/liter
Strontium-89	±25%	±20%	±15%
Strontium-90	±15%	±10%	±10%
Iodine-131	±50%	±20%	±10%
Cesium-137	±60%	±25%	±10%

[a] All errors are 2σ values, representing 95 percent confidence.

TABLE 10.—CALCIUM, POTASSIUM AND RADIONUCLIDES IN CANADIAN WHOLE MILK, FEBRUARY 1964[a]

[Radionuclide concentrations in pc/liter]

Station	Calcium (g/liter)	Potassium (g/liter)	Strontium-90	Cesium-137
Calgary	1.35	1.5	52.1	290
Edmonton	1.38	1.6	35.1	244
Ft. William	1.33	1.6	52.1	300
Fredericton	1.44	1.7	55.6	379
Halifax	1.28	1.6	45.4	289
Montreal	1.26	1.7	38.4	274
Ottawa	1.29	1.7	32.7	230
Quebec	1.22	1.7	45.6	347
Regina	1.31	1.6	48.3	208
St. John's, Nfld	1.27	1.7	50.9	264
Saskatoon	1.31	1.6	48.2	222
Sault Ste. Marie	1.33	1.6	37.8	194
Toronto	1.35	1.7	19.9	140
Vancouver	1.35	1.6	36.6	269
Windsor	1.33	1.7	17.2	112
Winnipeg	1.23	1.6	45.6	244
Average	1.31	1.6	41.3	250

[a] Due to insignificant levels of Sr^{89} the reporting of this radionuclide has been discontinued.

Results

Table 10 presents monthly averages of strontium–89, strontium–90, cesium–137, and stable calcium and potassium in Canadian whole milk. Spot checks for iodine–131 indicate that all samples had <5 pc/liter.

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(*6*) Kahn, B., et al.: *Rapid Methods for Estimating Fission Product Concentrations in Milk, Public Health Service Publication No. 999–R–2,* (March 1963). Single copies available on request from Public Inquiries Branch, PHS, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

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MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN PASTEURIZED MILK, MARCH 1963—FEBRUARY 1964

Division of Radiological Health, Public Health Service

Radionuclide concentration values reported by the Pasteurized Milk Network (*1*) can be used to estimate the contribution of milk to a population's radiation exposure. This is done by determining both the annual average concentrations of specific radionuclides in milk and the average daily milk consumption of a representative individual in a suitable sample of the population.

The data listed in table 1 are concerned with the first of these requirements, *i.e.*, annual average concentrations of strontium–89, strontium–90, iodine–131 and cesium–137 in one liter of pasteurized milk. Limited data are available for estimating the average daily milk consumption (on a volume basis) for specific age groups in the U. S. population (*2, 3*).

To arrive at a basis of comparison between the daily rates of intake of the radionuclides from the milk component of the diet and the Federal Radiation Council's ranges of transient daily rates of intake (*4*), it is assumed that the average daily milk consumption of an individual in a population group is one liter. The Guides, however, apply to total intake from all foods, and milk levels provide an index of general intake trends. The upper limits of Range II correspond to the Radiation Protection Guide (RPG) for iodine–131 and one third of the Radiation Protection Guide for radioactive strontium. The Guides are, for administrative reasons, expressed as a yearly radiation dose, but are based on lifetime exposure (*5*). The FRC emphasizes that the annual acceptance risk or exposure dose is not a dividing line between safety and danger in actual radiation situations (*6*).

Annual averages of radionuclide concentrations in milk sampled by the PHS Pasteurized Milk Network are presented in table 1. The data in table 1 are calculated as follows: (a) results from all samples collected in each week (Sunday through Saturday) are averaged, (b) the averages for all weeks terminating in each of twelve consecutive months are averaged to obtain the annual average.[1] To obtain the annual average daily intake (pc/day) of radionuclides from milk, the annual average concentration values (pc/liter) in table 1 must be multiplied by the annual average daily consumption (liters/day) of milk (*3, 4*).

Monthly variations of radionuclide concentrations in milk are influenced by a number of combined causes such as weather conditions and dairying practices. The moving yearly average (table 1), obtained by updating the previous twelve-month average by one month, shows variations averaged over the year and tends to minimize purely seasonal variations. This method, therefore, shows trends over a considerable period of time.

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[1] Beginning with the October 1963 data, iodine–131 values of <10 pc/liter are considered to be zero for averaging purposes; previously 5 pc/liter was used in calculating the average.

Table 1.—MOVING ANNUAL AVERAGE RADIONUCLIDE CONCENTRATIONS IN MILK

[Concentrations in pc/liter]

Sampling locations		Strontium-89		Strontium-90		Iodine-131		Cesium-137	
		Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]	Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]	Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]	Feb. 1963—Jan. 1964 [a]	Mar. 1963—Feb. 1964 [b]
Ala:	Montgomery	53	46	21	22	3	3	80	85
Alaska:	Palmer	29	29	22	23	3	3	123	132
Ariz:	Phoenix	11	9	4	4	3	3	22	22
Ark:	Little Rock	101	91	43	43	5	3	154	160
Calif:	Sacramento	37	36	10	11	3	3	61	63
	San Francisco	67	62	14	14	3	3	74	77
Colo:	Denver	25	24	17	17	5	4	84	86
Conn:	Hartford	21	21	24	24	3	3	152	161
Del:	Wilmington	27	27	25	25	4	3	127	133
D. C:	Washington	37	37	20	20	3	3	96	100
Fla:	Tampa	28	24	14	15	5	3	221	225
Ga:	Atlanta	76	67	30	31	4	3	142	148
Hawaii:	Honolulu	31	28	11	11	5	3	75	76
Idaho:	Idaho Falls	49	47	24	27	3	3	140	154
Ill:	Chicago	18	18	21	21	3	3	107	113
Ind:	Indianapolis	28	27	23	24	3	3	97	102
Iowa:	Des Moines	56	54	25	26	3	3	91	93
Kans:	Wichita	39	37	19	20	3	3	72	74
Ky:	Louisville	82	79	32	33	3	3	108	113
La:	New Orleans	123	101	43	44	7	5	154	156
Maine:	Portland	26	25	31	32	3	3	200	209
Md:	Baltimore	46	45	21	21	3	3	119	123
Mass:	Boston	31	30	34	36	3	3	219	232
Mich:	Detroit	16	16	20	20	3	3	110	114
	Grand Rapids	17	17	20	21	4	3	115	120
Minn:	Minneapolis	47	46	30	32	3	3	148	153
Miss:	Jackson	115	98	36	37	5	3	113	116
Mo:	Kansas City	63	61	27	28	3	3	83	86
	St. Louis	46	45	22	23	3	3	85	88
Mont:	Helena	45	43	27	28	4	3	171	182
Nebr:	Omaha	47	46	25	26	3	3	95	97
Nev:	Las Vegas	17	15	9	10	4	3	69	72
N. H:	Manchester	29	28	33	34	5	3	242	254
N. J:	Trenton	21	21	21	22	3	3	119	124
N. Mex.	Albuquerque	19	18	10	10	3	3	43	46
N. Y:	Buffalo	21	21	23	23	3	3	133	141
	New York	29	29	29	30	3	3	156	165
	Syracuse	24	23	23	24	4	3	130	138
N. C:	Charlotte	63	61	31	32	3	3	119	123
N. Dak:	Minot	81	80	50	53	4	3	136	143
Ohio:	Cincinnati	34	33	26	26	4	3	89	95
	Cleveland	23	22	21	22	3	3	103	110
Okla.	Oklahoma City	58	53	23	24	4	3	87	90
Ore:	Portland	67	63	29	31	3	3	157	162
Pa:	Philadelphia	25	25	24	23	3	3	120	126
	Pittsburgh	33	32	29	29	4	3	144	151
P. R:	San Juan	57	45	14	14	6	3	88	87
R. I:	Providence	25	25	27	28	4	3	159	169
S. C:	Charleston	59	47	27	28	5	3	123	128
S. Dak:	Rapid City	64	62	37	40	4	3	147	154
Tenn:	Chattanooga	95	91	37	39	3	3	140	146
	Memphis	80	73	31	32	3	3	88	90
Tex:	Austin	25	22	9	9	3	3	45	47
	Dallas	58	51	21	21	5	3	80	82
Utah:	Salt Lake City	32	31	23	24	5	4	153	162
Vt:	Burlington	25	25	28	29	3	3	171	181
Va:	Norfolk	43	40	22	22	3	3	100	103
Wash:	Seattle	53	51	25	25	3	3	149	150
	Spokane	49	47	27	29	4	3	137	141
W. Va:	Charleston	64	62	29	30	4	3	98	103
Wis:	Milwaukee	18	17	19	19	4	3	113	121
Wyo:	Laramie	37	35	21	22	3	3	115	115
Network average		45	42	24.4	25.2	4	3	119	124

[a] Annual averages were computed on basis of 52 weekly averages.

[b] Annual averages were computed on basis of 53 weekly averages.

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STRONTIUM-90 IN 1963 UNITED STATES WHEAT

V. F. Pfeifer and A. J. Peplinski[1]

Studies are being conducted by the United States Department of Agriculture's Northern Regional Research Laboratory to develop processing methods for reducing strontium-90 in wheat and milling products, should this become necessary. The first phase of these studies was the analysis of 1963 wheat samples from major U. S. wheat producing areas. This crop year was chosen because strontium-90 levels were expected to be the highest for several years, according to Federal Radiation Council predictions (*1*).

Wheat samples of at least 100 pounds for each variety were procured from commercial producers in 6 States. Each lot of wheat was blended thoroughly, sampled, and cleaned in a dockage tester to remove chaff and dust before analysis. Analyses for strontium-90 were performed by a contractor using analytical procedures described by Harley (*2*). Analyses for protein, ash, and calcium were made at this laboratory using Cereal Laboratory Methods 46-10, 08-01, and 40-20, respectively (*3*).

The results in table 1 show that the lowest levels of strontium-90 contamination were in the Pacific Northwest soft white winter (SWW) wheats and in the Ohio soft red winter (SRW) wheats. Highest levels were found in the Kansas hard red winter (HRW) wheats. These results indicate levels reached in 1963; sampling was not sufficiently extensive to be considered representative.

The three Pacific Northwest wheats, grown on the same type of soil in the Pullman, Washington, area, varied in strontium-90 content from 76 to 119 pc/kg (dry weight). The six Indiana SRW wheats, grown in the Huntingdon area on the same type of soil, had strontium-90 levels ranging from 258 to 338 pc/kg. Wichita and Comanche varieties of HRW wheat, grown on the same type of soil in the Kinsley, Kansas, area, had practically identical strontium-90 levels.

The 1963 strontium-90 levels in wheat are about three times as high as the 1962 levels (*4*), confirming the predictions of 250 pc/kg by the Federal Radiation Council (*1*) and 200-300 pc/kg by Rivera (*5*).

TABLE 1.—STRONTIUM-90 IN U.S. WHEATS HARVESTED IN 1963

[Calculated on dry basis [1]]

Variety	Class	Grown in vicinity of:	Protein (Percent)	Ash (Percent)	Calcium (Percent)	Strontium-90 (pc/kg)
Brevor	[2] SWW	Pullman, Wash.	12.2	1.70	0.037	90
Gaines	SWW	Pullman, Wash.	9.0	1.60	0.036	76
Omar	Club	Pullman, Wash.	9.0	1.60	0.039	119
Lakota	Durum	Carrington, N. Dak.	17.4	1.89	0.036	147
Wells	Durum	Carrington, N. Dak.	18.4	1.84	0.037	182
Tascosa	[3] HRW	Johnson, Kans.	14.0	2.02	0.054	495
Kaw	HRW	Johnson, Kans.	13.6	1.93	0.045	359
Wichita	HRW	Kinsley, Kans.	14.3	1.91	0.056	253
Comanche	HRW	Kinsley, Kans.	13.7	1.70	0.056	250
Ponca	HRW	Partridge, Kans.	17.2	1.71	0.058	253
Pawnee	HRW	Partridge, Kans.	13.6	1.58	0.043	439
Triumph	HRW	Partridge, Kans.	15.3	1.72	0.039	465
Bison	HRW	Hays, Kans.	15.9	1.77	0.057	417
Ponca	HRW	Peoria, Ill.	11.3	1.96	0.039	87
Dual	[4] SRW	Huntingdon, Ind.	12.9	1.97	0.050	338
Vermillion	SRW	Huntingdon, Ind.	12.2	1.81	0.048	319
Reed	SRW	Huntingdon, Ind.	14.1	1.89	0.042	329
Laporte	SRW	Huntingdon, Ind.	13.8	1.65	0.041	258
Redcoat	SRW	Huntingdon, Ind.	13.3	2.09	0.050	285
Monon	SRW	Huntingdon, Ind.	12.2	2.01	0.038	296
Seneca	SRW	Sandusky, Ohio	11.8	1.77	0.049	111
Lucas	SRW	Sandusky, Ohio	10.7	1.56	0.037	60
Thorne	SRW	Sandusky, Ohio	11.2	1.81	0.049	110

[1] Wheat moisture contents varied from 10.3 to 14.0 percent.
[2] SWW indicates soft white winter wheat.
[3] HRW indicates hard red winter wheat.
[4] SRW indicates soft red winter wheat.

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(*5*) Rivera, J.: Private communication (1963).

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STRONTIUM-90 IN PLANT PARTS AND MILLING FRACTIONS FROM A 1963 ILLINOIS WHEAT

V. F. Pfeifer, A. J. Peplinski, and J. E. Hubbard[1]

Plant parts and milling fractions of wheat are being analyzed for strontium-90 as a part of the studies by the U. S. Department of Agriculture's Northern Regional Research Laboratory to develop processing methods for reducing the radionuclide content of these products, should this become necessary.

Following nuclear testing through 1962, levels of radioactive contamination of wheat were predicted to reach maximum values in 1963 and then to decrease (*1*). Therefore, a field of wheat in central Illinois was chosen for collection of 1963 wheat plants and field-combined wheat to obtain data on strontium-90 in aboveground plant parts and in milling fractions from both hand-separated and field-combined wheats from the same field. Strontium-90 in wheats and milling products for previous years has been reported by Rivera (*2–4*).

Procedures

Ponca hard red winter wheat plants, 1963 crop, grown on a field in Hollis Township, Peoria County, Illinois, were cut near the ground, and about 100 pounds of the aboveground parts were hand-separated to provide sufficient quantities of leaves, stems, rachises, chaff, and wheat kernels for analyses and determination of weight distribution of the parts. Enough additional plants were hand-threshed and hand-separated to provide sufficient wheat for milling in a Buhler experimental flour mill.[2] The hand-separated wheat kernels were cleaned in a Bates laboratory aspirator before milling. About 30 pounds of wheat combined in the same field were mechanically cleaned by several passages through a Federal dockage tester, and the cleaned wheat was milled in a Miag Multomat experimental flour mill. Strontium-90 analyses of plant parts and milling fractions were done by a contract laboratory using analytical procedures described by Harley (*5*). Analyses for protein, ash, and calcium were made at the Northern Laboratory, using Cereal Laboratory Methods 46-10, 08-01, and 40-20, respectively (*6*).

Results and Discussion

The weight distribution measurement and chemical analyses of the aboveground plant parts are given in table 1. Milling results and chemical analyses of the various fractions obtained after milling the hand-separated kernels are given in table 2. Milling results and chemical analyses of fractions obtained after milling the field-combined wheat are given in table 3.

The nitrogen content of all plant parts except leaves and kernels was low. Patent and first clear flours were lower in protein content than the wheat, whereas second clear flour, shorts, and bran were all higher in protein content than the original grain. After milling, the flour retained about one-fourth of the calcium but less than one-fifth of the ash.

Although the wheat kernels amounted to almost one-half of the weight of the aboveground plants, they contained less than one-tenth of the total strontium-90 present in the plants. Highest concentrations were in the leaves and in the chaff, and these two fractions together contained about three-fourths of that present. In the plant parts, strontium-90 calcium ratios ranged from 212 pc strontium-90 gram calcium in the kernels to 1206 in the chaff. Strontium-90 in the ash ranged from 3.8 pc gram in the kernels to about 22 in the leaves and rachises, but was only 11.3 in the chaff.

Wheat kernels separated by hand-picking, and cleaned by aspiration, contained somewhat less strontium-90 than did the field-combined, mechanically cleaned wheat; all milling fractions from the hand-separated wheat contained less strontium-90 than corresponding fractions from the field-combined wheat. The importance of cleaning wheat properly before milling is thus demonstrated, since the Miag mill, with its longer and more extensive milling flow,

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[1] Mr. Pfeifer and Mr. Peplinski are chemical engineers and Mr. Hubbard is Assistant to the Director at the Northern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture located at Peoria, Illinois.

[2] Mention of firm names or trade products does not imply that they are endorsed or recommended by the Department of Agriculture over other firms or similar products not mentioned.

TABLE 1.—WEIGHT DISTRIBUTION AND ANALYSES OF ABOVEGROUND WHEAT PLANT PARTS

[Analyses on dry basis]

Aboveground plant part	Weight (Percent)	Nitrogen (Percent)	Ash (Percent)	Calcium (Percent)	Sr^{90} (pc/kg)	Sr^{90} in fraction (Percent of total)
Stems	25.2	0.27	3.00	0.063	310	14
Leaves	10.3	0.74	8.09	0.295	1904	36
Rachises	2.6	0.35	3.22	0.082	738	4
Chaff (glumes, awns etc.)	11.3	0.63	13.19	0.124	1495	39
Wheat kernels	47.6	2.01	2.01	0.036	76	7

TABLE 2.—STRONTIUM-90 IN MILLING FRACTIONS FROM HAND-PICKED WHEAT KERNELS

[Analyses on dry basis]

Fraction	Yield (Percent)	Protein (Percent)	Ash (Percent)	Calcium (Percent)	Sr^{90} (pc/kg)	Sr^{90} in fraction (Percent of total)
Wheat	—	11.5	2.01	0.036	[a] 76.5	100
Patent flour	57.7	9.9	0.49	0.011	10.3	8
Clear flour	13.2	10.9	0.62	0.014	17.3	3
Shorts	7.5	[b] 16.9	3.21	0.069	113	11
Bran	21.6	[b] 15.1	6.65	0.114	282	78

[a] Sr^{90} in wheat, calculated from milling fractions = 77.6.

[b] Nitrogen content × 6.25.

should have given a better separation of flour and feed fractions than the Buhler mill.

In the milling fractions from the hand-picked wheat, strontium-90/calcium ratios varied from 94 pc strontium-90/gram calcium in the patent flour to 247 in the bran, with 212 in the wheat. Strontium-90 in the ash varied from 2.1 pc/gram in the patent flour to 4.2 in the bran, with 3.8 in the wheat.

In the milling fractions from the field-combined wheat, strontium-90/calcium ratios varied from 131 pc strontium-90/gram calcium in the patent flour to 313 in the bran, with 223 in the wheat. Strontium-90 in the ash varied from 4.0 pc/gram in the patent flour to 6.6 in the shorts, with 4.4 in the wheat.

Considering that each one-pound loaf of white bread contains nearly two thirds of a pound (about 280 grams) of white flour, the importance of effective milling for reducing strontium-90 in the flour, and the need for diverting the more highly-contaminated bran and shorts fractions to feeds can be appreciated. The flour milled from wheat contains only about 1 percent of the total strontium-90 present in the aboveground wheat plants. Wheat is thus a good raw material for producing fractions suitable for use in foods under conditions of high-density fallout, although accompanying diet modification might be required with prolonged and concentrated consumption.

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STRONTIUM-90 AND CALCIUM IN TRI-CITY DIETS, AUGUST-OCTOBER 1963[1]

J. Rivera[2]
Health and Safety Laboratory, AEC

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium-90 content of the average diet of individuals living in New York City, San Francisco, and Chicago.

Selected foods representing 19 food categories are purchased at each of these three cities about every 3 months and are analyzed for strontium-90. Using data from the U. S. Department of Agriculture (*1*), the annual consumption by an average individual can be grouped into the same 19 food categories. The annual dietary intake of strontium-90 can be estimated by summing the contributions from each category. Some food types are assumed to be representative of larger food categories, such as liquid milk for dairy products in general. Details of the sampling system and assumptions as to the amounts of specific foods consumed per year have been published (*2*).

The consumption data from the "Household Food Survey of 1955" are based on a weight-as-purchased basis. Before the food samples for the Tri-City Diet Study are ashed for radiochemical analysis, they are prepared to a certain degree as if for actual consumption. For example, fruits are peeled, eggs are shelled, and poultry is boned. Therefore, concentrations of radioactivity in foods as reported in the Tri-City Diet Study are based on the trimmed weight. No correction is made for the waste.

After two samplings at each city it was found that the calcium content of most food categories did not vary among cities, nor did it vary significantly with time. Calcium analyses were therefore discontinued and average calcium content of foods was computed and used to estimate the average annual intake of this mineral. The specific numbers used to calculate calcium intake are given in HASL-113 (*3*).

To increase the validity of this estimate an additional set of diet samples from each city have recently been analyzed for calcium. The results of these analyses together with those previously obtained are presented in table 1. The estimated average yearly intake of calcium calculated using all of the data remains at 383 g/year. No essential differences in the calcium content of foods purchased at each city were noted. There was also no evidence of changes in calcium concentrations of foods with time. In view of these findings, routine calcium analyses of tri-city foods will no longer be done.

Results obtained from the program's fourteenth sampling (August-October 1963) are presented in table 2. The variation with time of the daily intake of strontium-90 in the three cities is plotted in figure 1.

Discussion

The daily intakes of strontium-90 at New York City and Chicago are seen to be more nearly the same during the last half of 1963 than they were for the first half of the year. The daily intake of strontium-90 in New York City seems to have leveled off at about 35 pc/day and it is likely that the intake at Chicago also leveled off during late 1963 at a value slightly less than that of New York. The daily intake of strontium-90 at San Francisco appeared to have passed its peak for 1963, but results of the December sampling will have to be evaluated before this is established with certainty.

If for a given dietary regimen the ratio of Sr^{90}/Ca (strontium units) in the total diet to Sr^{90}/Ca in milk is constant, then estimates of total diet Sr^{90}/Ca could be made using only data on the Sr^{90}/Ca of milk.

The total diet-milk Sr^{90}/Ca ratios obtained using data from the Tri-City Diet Studies are plotted in figure 2. From this graph the ratio is seen to have varied from 1.0 to 2.0, with no apparent trend with time or difference among cities noted, since 1960. If a mean value of 1.5 were taken for the total diet-milk ratio, then estimates of total diet Sr^{90}/Ca made from milk Sr^{90}/Ca would not have been in error by more than ±50%.

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[1] Summarized from *Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL 144*: 281-7, Office of Technical Services Department of Commerce, Washington, D. C. 20230, (April 1, 1964), price $4.00.

[2] Mr. Rivera is a physicist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U. S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

The relative constancy of the diet-milk ratio implies that the Sr^{90}/Ca of the non-milk component of the diet has been roughly proportional to the Sr^{90}/Ca of milk. The Sr^{90}/Ca ratios of the non-milk components and the milk components of the diet in New York, Chicago, and San Francisco are plotted in figures 3 and 4, respectively. The ratio of these values (Sr^{90}/Ca of non-milk component ÷ Sr^{90}/Ca of milk component) is shown in figure 5. For each city it appears that on the average the Sr^{90}/Ca of the non-milk component of the diet has been about twice that of milk.

TABLE 1.—CALCIUM IN DIETARY CONSTITUENTS AND CALCULATED ANNUAL CALCIUM INTAKES

Food category	Average U.S. consumption (kg/yr)[1]	Grams of calcium per kilogram of original material									Mean ± standard deviation g (Ca/kg)	Calcium intake (g/yr)
		New York			Chicago			San Francisco				
		3/60	6/60	11/63	5/60	9/60	11/63	3/60	8/60	11/63		
White bread	37	0.74	1.30	1.62	0.92	1.25	0.91	0.81	1.09	1.05	1.06 ±0.27	39.2 ± 1.0
Whole wheat bread	11	0.68	0.98	1.16	0.95	1.04	0.85	0.93	0.90	0.79	0.92 ±0.14	10.1 ± 1.5
Eggs	16	1.78	0.58	0.58	0.54	0.47	0.66	0.65	0.61	0.56	0.58 ±0.42	9.3 ± 6.7
Fresh vegetables	43	0.47	0.32	0.38	0.36	0.34	0.35	0.27	0.35	0.32	0.35 ±0.05	15.0 ± 2.1
Root vegetables	17	0.57	0.32	0.26	0.38	0.16	0.44	0.41	0.31	0.44	0.37 ±0.12	6.3 ± 0.20
Milk	221	1.05	1.09	1.09	0.99	1.09	0.92	1.05	1.08	1.15	1.05 ±0.06	231.3 ±13.3
Chicken	17	0.36	0.15	0.35	0.79	1.04	0.49	0.32	0.58	0.33	0.48 ±0.27	8.2 ± 4.6
Fresh fish	8	1.61	1.10	0.14	1.55	1.26	0.55	1.24	0.64	1.33	1.12 ±0.43	9.0 ± 3.4
Flour	43	0.21	0.18	0.19	0.20	0.09	0.23	0.20	0.19	0.19	0.20 ±0.04	8.6 ± 1.7
Macaroni	3	0.23	0.18	0.16	0.22	0.26	0.22	0.20	0.22	0.23	0.21 ±0.03	0.6 ± 0.09
Rice	3	0.49	0.38	0.20	0.19	0.25	0.21	0.30	0.58	0.31	0.32 ±0.13	1.0 ± 0.4
Meat	73	0.09	0.09	0.30	0.09	0.09	0.14	0.14	0.12	0.08	0.16 ±0.12	11.7 ± 8.3
Shellfish	1	1.34	0.75	2.64	0.59	0.48	0.45	0.79	0.88	2.74	1.17 ±0.91	1.17 ±0.9
Dried beans	3	0.59	0.68	0.84	1.45	1.16	1.68	1.05	0.84	1.14	1.05 ±0.38	3.1 ± 1.1
Fresh fruit	68	0.16	0.21	0.12	0.21	0.23	0.16	0.31	0.05	0.22	0.19 ±0.07	12.9 ± 4.8
Potatoes	45	0.08	0.16	0.06	0.14	0.10	0.12	0.16	0.12	0.08	0.11 ±0.03	4.9 ± 1.3
Canned fruit	26	0.05	0.05	0.04	0.05	0.05	0.07	0.05	0.05	0.04	0.05 ±0.00	1.3 ± 0.0
Fruit juices	19	0.09	0.09	0.08	0.08	0.11	0.14	0.08	0.14	0.10	0.09 ±0.02	1.7 ± 0.04
Canned vegetables	20	0.14	0.23	0.22	0.20	0.23	0.22	0.25	0.23	0.21	0.21 ±0.03	4.2 ± 0.6
Average total calcium intake per year (grams/year)												382.6 ±19.2

[1] Based on USDA Household Food Consumption Survey (1).

TABLE 2.—AVERAGE PER PERSON DIETARY CONSUMPTION AND STRONTIUM-90 INTAKE—FOURTEENTH SAMPLING

Food category	Average U.S. consumption		New York City August 1963		Chicago October 1963		San Francisco September 1963	
	diet (kg/yr)	Calcium (g/yr)	(pc/kg)*	(pc/yr)	(pc/kg)*	(pc/yr)	(pc/kg)*	(pc/yr)
Bakery products	37	37.0	22.9 ±1.1	847	29.2 ±1.1	1080	16.5 ±1.1	610
Whole grain products	11	10.0	28.1 ±1.2	309	72.6 ±1.9	799	27.4 ±1.4	301
Eggs	16	9.1	11.2 ±0.3	179	6.0 ±0.3	96	3.3 ±0.2	53
Fresh vegetables	43	15.0	13.5 ±0.8	580	26.0 ±0.7	1118	3.3 ±0.3	142
Root vegetables	17	6.1	5.2 ±0.3	88	10.5 ±0.6	178	6.4 ±0.5	109
Milk	221	234.3	41.9 ±0.9	9260	19.6 ±0.6	4332	7.0 ±0.4	1547
Poultry	17	9.2	3.2 ±0.1	54	3.0 ±0.1	51	2.1 ±0.1	36
Fresh fish	8	10.8	1.1 ±0.1	9	1.9 ±0.1	15	1.1 ±0.1	9
Flour	43	8.6	17.9 ±0.4	770	29.8 ±7.0	1281	22.9 ±0.6	985
Macaroni	3	0.7	9.4 ±0.4	28	22.6 ±0.5	68	12.0 ±0.5	36
Rice	3	1.1	2.6 ±0.3	8	5.9 ±0.3	18	7.4 ±0.4	22
Meat	73	10.9	1.4 ±0.1	102	2.1 ±0.1	153	2.7 ±0.1	197
Shellfish	1	0.8	5.8 ±0.2	6	0.9 ±0.3	1	1.8 ±0.2	2
Dried beans	3	2.9	14.8 ±1.7	44	37.9 ±1.9	114	18.5 ±2.3	56
Fresh fruit	68	13.6	3.2 ±0.2	218	2.8 ±0.1	190	2.8 ±0.3	190
Potatoes	45	5.8	10.1 ±0.8	454	4.5 ±0.5	202	3.2 ±0.6	144
Canned fruit	26	1.3	1.9 ±0.1	49	2.7 ±0.1	70	2.5 ±0.2	65
Fruit juices	19	1.7	5.2 ±0.4	99	4.1 ±0.3	78	4.2 ±0.3	80
Canned vegetables	20	4.2	7.8 ±0.6	156	18.4 ±0.7	368	2.5 ±0.4	50
Annual Intake	674	383		13,200		10,212		4634
pc Sr^{90}/g Ca in total diet				34.6		26.7		12.1

* Error terms are one standard deviation (due to counting).

Another inference that can be drawn is that the relatively low Sr^{90}/Ca of the non-milk components of the diet in San Francisco are probably due to the consumption of locally-produced foods. Thus, despite the wide distribution of foods in the United States, foods produced in the relatively low fallout regions of California were probably the principle sources of the non-milk foods consumed in San Francisco.

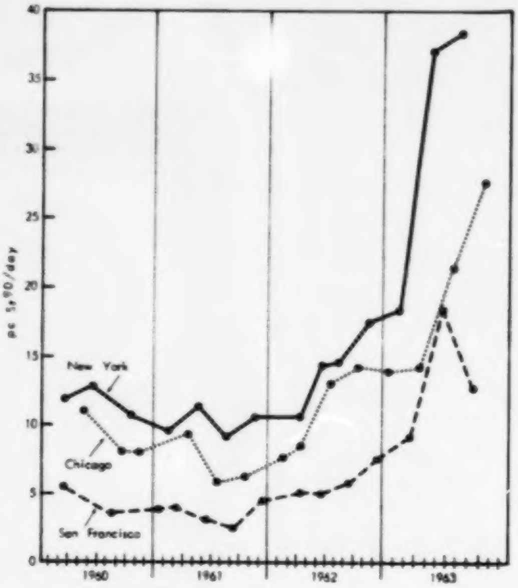

Figure 1.—DAILY INTAKE OF STRONTIUM-90 IN TRI-CITY TOTAL DIETS

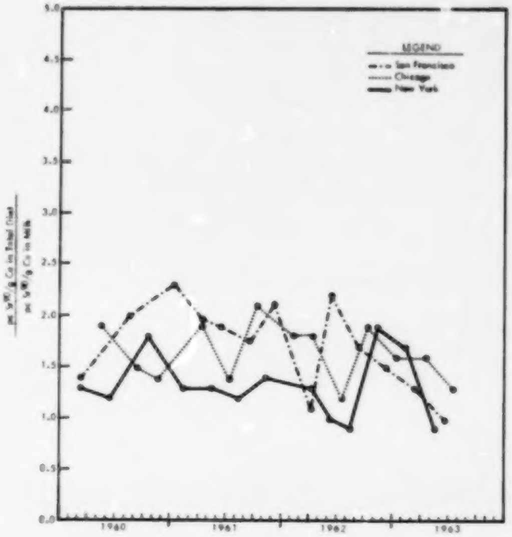

Figure 2.—RATIO OF STRONTIUM UNITS IN TOTAL DIET TO STRONTIUM UNITS IN MILK

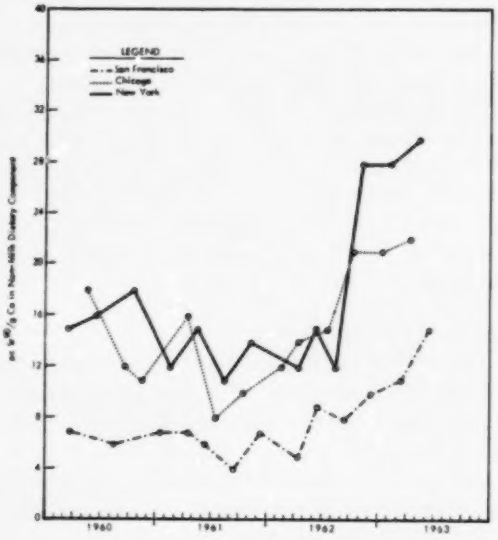

Figure 3.—STRONTIUM UNITS IN NON-MILK COMPONENTS OF TRI-CITY DIETS

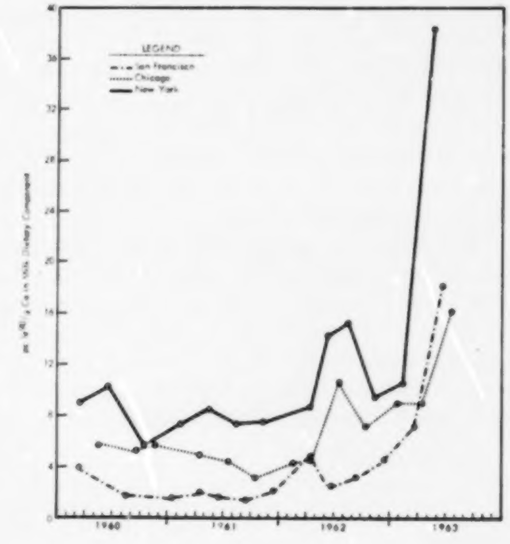

Figure 4.—STRONTIUM UNITS IN THE MILK COMPONENTS OF TRI-CITY DIETS

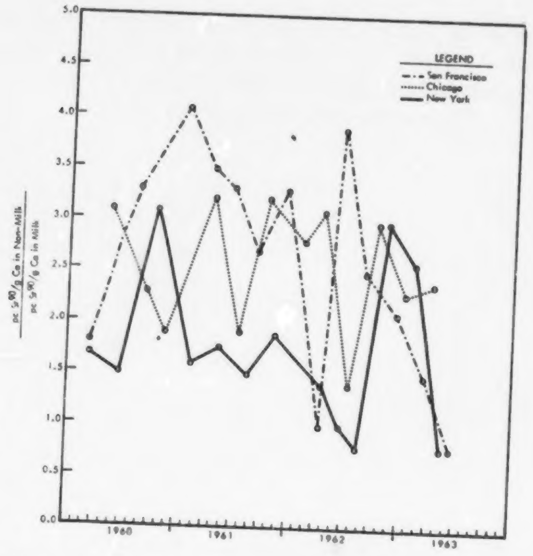

FIGURE 5.—RATIO OF STRONTIUM UNITS IN NON-MILK COMPONENTS OF TOTAL DIET TO STRONTIUM UNITS IN MILK

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(*2*) U. S. Atomic Energy Commission: *Health and Safety Laboratory, Fallout Program Quarterly Summary Report, HASL–90:* 15–24, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (August 1960), price $4.00.

(*3*) U. S. Atomic Energy Commission: *Health and Safety Laboratory, Fallout Program Quarterly Summary Report, HASL–113:* 85–89, Office of Technical Services, Department of Commerce, Washington, D.C. 20230 (July 1, 1961), price $2.50.

CESIUM-137 IN TRI-CITY DIETS,[1] AUGUST-OCTOBER 1963

J. Rivera and J. J. Kelly[2]

Since March 1960, the Health and Safety Laboratory, through its quarterly diet study, has made estimates of the strontium–90 content of the average diets of individuals living in New York City, San Francisco, and Chicago (see preceding article, p. 2–42). Occasionally, some samples from this study are analyzed for other radionuclides. The samples for October-December 1963 were analyzed for the fission product cesium–137.

Because Cs^{137} is thought to be less hazardous than Sr^{90}, comparatively little effort has been made in this country to measure its concentration in the diet as a whole, or in components of the diet. Anderson *et al.* (*1*) showed that Cs^{137} levels in fallout, milk, and people could be related, but a number of assumptions as to the magnitude of the contamination of non-milk fractions of the diet, and the time lag between production and consumption of these foods had to be made before good agreement between observation and theory could be obtained.

In an attempt to verify these assumptions and to obtain more data on which to base predictions of future body levels of Cs^{137} in humans, a limited number of samples from the Tri-City Diet Study are being analyzed for Cs^{137}. The results of the first set of these analyses are presented in table 1.

Analytical Method

The radiochemical analysis of the food composites was accomplished using the method of Collins, Sutton, and Solazzi, developed in this laboratory (*2*).

Cesium–137 and added cesium carrier are equilibrated by fusion with sodium carbonate or, with soluble samples, by digestion of the sample in nitric acid. Bulk constituents, including iron, the alkaline earths and the rare earths, are removed by leaching the alkali metals from

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[1] Data from *Health and Safety Laboratory, AEC, Fallout Program Quarterly Summary Report, HASL–144:* 288–90, Office of Technical Services, Department of Commerce, Washington, D. C. 20430 (April 1, 1964), price $4.00.

[2] Mr. Rivera is a physicist and Mr. Kelly is a chemist on the staff of the Environmental Studies Division, Health and Safety Laboratory, U.S. Atomic Energy Commission, 376 Hudson Street, New York, N.Y. 10014.

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TABLE 1.—AVERAGE PER PERSON DIETARY CONSUMPTION AND CESIUM-137 INTAKE, OCTOBER-DECEMBER 1963

Food category	U.S. consumption (kg/yr)	New York City November 1963		Chicago October 1963		San Francisco December 1963	
		pc/kg [a]	pc/yr	pc/kg [a]	pc/yr	pc/kg [a]	pc/yr
White bread	37	95.7±2.8	3,541	87.5±2.6	3,237	867.4± 8.4	32,092
Whole grain bread	11	239.5±4.7	2,634	181.5±3.9	1,997	877.7± 8.2	9,655
Eggs	16	33.0±0.5	528	33.1±0.4	534	6.8± 0.5	108
Fresh vegetables	43	18.7±0.7	804	14.8±0.8	636	31.3± 1.2	1,346
Root vegetables	17	26.3±0.9	447	15.2±0.9	258	24.8± 1.0	422
Milk	221	135.1±1.9	29,857	69.6±1.3	15,382	59.3± 1.2	13,105
Poultry	17	40.3±0.4	685	69.7±0.6	1,184	36.0± 0.7	612
Fresh fish	8	166.5±1.4	1,332	32.2±0.3	257	[illegible].7± 0.1	93
Flour	43	151.3±1.9	6,506	82.5±1.3	3,545	[illegible].0± 2.2	13,027
Macaroni	3	144.1±1.8	432	175.6±2.0	547	1[illegible].7± 1.7	371
Rice	3	130.3±1.7	391	52.4±1.0	157	181.8± 2.3	545
Meat	73	9.1±0.3	664	116.8±0.8	8,526	130.1± 0.8	9,496
Shellfish	1	13.0±0.5	13	6.3±1.7	6	54.2± 3.8	54
Dried beans	3	308.1±6.2	924	319.0±6.0	957	982.5±15.0	2,947
Fresh fruit	68	41.1±0.9	2,795	42.9±0.8	2,916	27.2± 0.7	1,846
Potatoes	45	61.1±1.7	2,749	13.3±0.9	597	19.9± 0.9	897
Canned fruit	26	21.5±0.4	559	19.5±0.4	508	85.2± 0.8	2,214
Fruit juices	19	68.3±1.3	1,298	36.4±0.9	692	318.5± 2.6	6,052
Canned vegetables	20	44.4±1.3	888	22.8±0.9	455	322.2± 3.7	6,444
Annual Intake	674		57,047		42,371		101,326
Daily Intake (pc/day)			156		116		278

[a] Error terms are one standard deviation (due to counting).

the fusion melt with water or by scavenging the hydrochloric acid solution with $Ca_3(PO_4)_2$ or $CaCO_3$. Calcium, rubidium and potassium are extracted from solution with solid ammonium phosphomolybdate (APM) and cesium is purified by absorption and selective elution from a cation exchange resin.

Chemical yield is determined by weighing the final cesium fraction as the tetraphenylborate. The Cs^{137}–Ba^{137} beta activity is measured using a thin window Geiger-Mueller counter or a plastic beta scintillation counter. The instrument response is corrected for counter background and efficiency, self absorption, and yield.

To establish the precision of the method when routine samples were being processed, three sets of blind duplicates were included with the other samples. The results indicated that the reproducibility of analyses was better than ± 10 percent. Three $Ca_3(PO_4)_2$ samples were also analyzed. In each case, Cs^{137} was undetectable, indicating that there was no Cs^{137} contamination and that therefore no reagent blank corrections were necessary.

An estimate of the accuracy of the method can be made by comparison of results among laboratories using different methods. Such a comparison made by analyzing a wheat and powdered milk sample obtained from the International Atomic Energy Agency showed that HASL results were within one standard deviation of the mean values reported by six other laboratories.

The results obtained from the analyses of nine monthly milk samples from a number of different cities were found to average about 25 percent lower than those reported by the Public Health Service. This intercomparison is not conclusive, however, since the Public Health Service results were obtained from pooled samples while in most cases the HASL data are from single samples. It is possible that a small ($<10\%$) fraction of the Cs^{137} in milk and perhaps in other foods was lost via volatilization during sample preparation. Experiments comparing results obtained on samples prepared by wet and dry ashing are currently in progress to establish quantitatively what effect this has on Cs^{137} recovery.

Discussion

Although conclusions from preliminary data are speculative, it appears that the elevated levels of cereal products observed in San Francisco sampling indicate that products from a different wheat crop than that being used in New York City or Chicago had reached the San Francisco market in December.

Since the 1963 wheat crop probably had a higher Cs^{137} contamination than any previous

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crop, it is likely that cereal products will contribute significantly to the daily intake of Cs^{137} and may become as important as milk and meat as dietary sources of Cs^{137}.

If dietary levels of Cs^{137} persist at about 200 pc/day, this would result in a body burden of roughly 20 nc. This body burden would result in a dose rate of only $^1/_{10}$ that due to natural potassium in the body.

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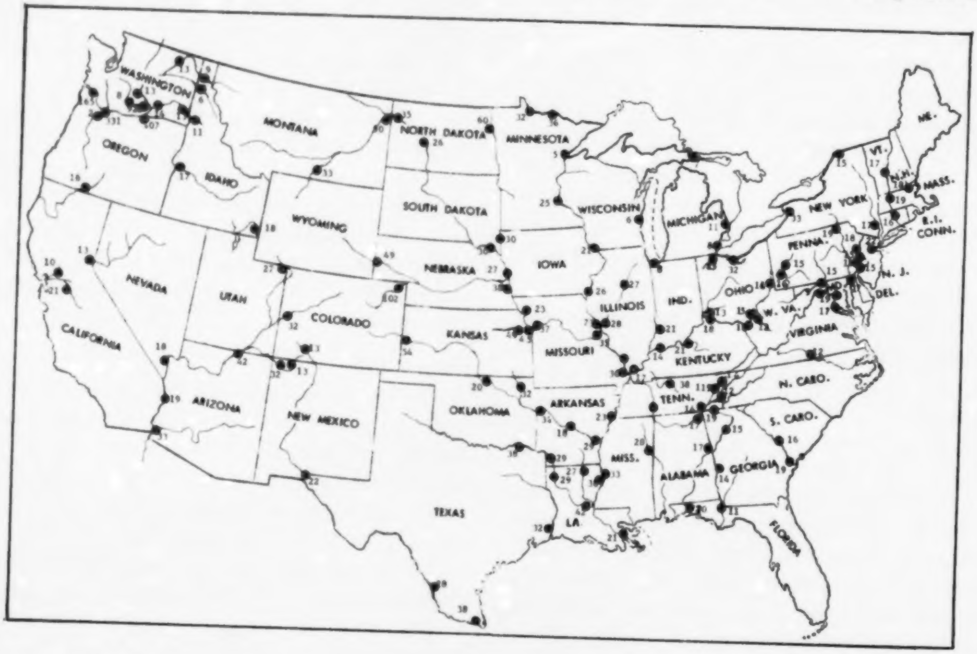
(*2*) U. S. Atomic Energy Commission: *Manual of Standard Laboratory Procedures, NYO-4700*, Health and Safety Laboratory, AEC, 376 Hudson St., New York, N. Y. 10014 (Revised August 1962).

Section III—Water

RADIOACTIVITY IN SURFACE WATERS OF THE UNITED STATES, DECEMBER 1963

Division of Water Supply and Pollution Control, Public Health Service

Levels of radioactivity in surface waters of the United States have been under surveillance by the Public Health Service Water Pollution Surveillance System (formerly National Water Quality Network) since its initiation in 1957. Beginning with the establishment of 50 sampling points, this System has expanded to 128 stations as of May 1, 1964. These are operated jointly with other Federal, State, and local agencies, and industry. Samples are taken from surface waters of all major U. S. river basins for physical, chemical, biological and radiological analyses. These data can be used for evaluating sources of radioactivity which may affect specific domestic, commercial, and recreational uses of surface water. Further, the System provides background information necessary for recognizing pollution and water quality trends and for determining levels of radioactivity to which the population may be subjected. Data assembled through the System are published in an annual compilation (*1–7*).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OREGON
CALIFORNIA
NEVADA
IDAHO
MONTANA
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ARIZONA
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NORTH DAKOTA
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NEBRASKA
KANSAS
OKLAHOMA
TEXAS
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IOWA
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GEORGIA
FLORIDA
S. CARO.
N. CARO.
VIRGINIA
W. VA.
PENNA.
NEW YORK
N. J.
DEL.
VT.
N.H.
ME.
MASS.
R.I.
CONN.
165
331
107
11
18
17
13
10
<21
19
51
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FIGURE 1.—TOTAL BETA ACTIVITY (pc/liter) IN SURFACE WATERS, DECEMBER 1963

Sampling Procedures

The participating agencies collect one-liter "grab" samples each week and ship them to the Surveillance System Laboratory in Cincinnati for analysis. Determinations of gross alpha and gross beta radioactivity in the suspended and dissolved solids and of strontium-90 activity in the total solids are carried out on frequency schedules based on need.

Presently, gross alpha and beta determinations are made on monthly composites of the weekly samples received from all stations, except those located downstream from known potential sources of radioactive waste and those from all newly established System stations. Weekly alpha and beta measurements are scheduled routinely during the first year of operation at newly established stations.

Normally, samples are counted within two weeks following collection or within one week after compositing. The decay of activity is followed on each sample when the first analysis shows unusually high activity. Also, if a recount indicates that the original analysis was questionable, values based on recounting are recorded. All results are reported for the time of counting and are not extrapolated to the time of collection.

Analytical Methods

The analytical method used for determining gross alpha and beta radioactivity is described in the eleventh edition of "Standard Methods for the Examination of Water and Wastewater" (*8*). Suspended and dissolved solids are separated by passing the sample through a membrane filter (type HA) with a pore size of 0.45 microns. Planchets are then prepared for counting the dissolved solids (in the filtrate) and the suspended solids (on the charred membrane filter) in an internal proportional counter. Reference sources of U_3O_8, which give a known count rate if the instrument is in proper calibration, are used for daily checking of the counters.

Since the fourth quarter of 1958, strontium-90 analyses have been made on three-month composites of aliquots from weekly samples. Beginning in November 1962, two quarterly samples per year have been analyzed for strontium-90 at each sampling point except those stations immediately below nuclear installations. At these stations four determinations per year are performed. The method used for determining strontium-90 is a modification of a procedure described by Harley (*9*). The yttrium-90, together with an yttrium carrier, is precipitated at pH 8.5; the precipitate is washed, redissolved, and reprecipitated as yttrium oxalate and the latter is washed and counted in a low-background anticoincidence, end-window proportional counter.

Results

Table 1 presents December 1963 results of alpha and beta analyses of U.S. surface waters. The stations on a river are arranged in the table according to their relative location on the river, the first station listed being closest to the headwaters. These data are preliminary. Replicate analyses of some samples as well as some analyses incomplete at the time of this report will be included in the System's Annual Compilation of Data (*7*). The figures for gross alpha and gross beta radioactivity represent either determinations on composite samples or means of weekly determinations where composites were not made. The monthly means are reported to the nearest pc/liter. When all samples have zero pc/liter, the mean is reported as zero and when the calculated mean is between zero and 0.5 the mean is reported as <1 pc/liter. The most recent quarterly strontium-90 results appeared in the January 1964 issue of *RHD* (*10*).

In order to obtain a geographical perspective of the radioactivity in surface water, the numbers alongside the various stations in figure 1 give the December 1963 average total beta activity in suspended-plus-dissolved solids in raw water collected at that station. Results for the years 1957–1962 have been summarized by Weaver *et al* (*11*).

Discussion

The monthly dissolved beta activity averages exceeded 200 pc/liter only on the Columbia River. Of the six stations on the Columbia River, the four downstream from the Hanford Atomic Products Operations facility had averages of between 148 and 866 pc/liter. It can be observed that the concentration diminishes with distance downstream from the facility.

The dissolved alpha activity, which is associated with the dissolving of natural surface minerals by water, ranged in monthly averages

TABLE 1.—RADIOACTIVITY IN RAW SURFACE WATERS, DECEMBER 1963

(Average concentrations in pc/liter)

Station	Beta activity			Alpha activity		
	Suspended	Dissolved	Total	Suspended	Dissolved	Total
Allegheny River:						
Pittsbugh, Pa	4	11	15	0	0	0
Animas River:						
Cedar Hill, N. Mex	2	11	13	<1	3	3
Apalachicola River:						
Chattahoochee, Fla	2	9	11	0	0	0
Arkansas River:						
Coolidge, Kansas	9	45	54	1	51	52
Ponca City, Okla	0	20	20	0	4	4
Fort Smith, Ark	6	28	34	0	3	3
Little Rock, Ark	3	15	18	0	1	1
Pendleton Ferry, Ark	7	22	29	1	2	3
Bear River:						
Preston, Idaho	5	13	18	0	2	2
Big Horn River:						
Hardin, Mont	8	25	33	1	8	9
Big Sioux River:						
Sioux Falls, S. Dak	4	26	30	0	5	5
Chattahoochee River:						
Atlanta, Ga	6	9	15	0	0	0
Columbus, Ga	3	11	14	0	0	0
Lanett, Ala	8	9	17	1	0	1
Chena Slough:						
Fairbanks, Alaska	1	3	4	0	0	0
Clearwater River:						
Lewiston, Idaho	3	8	11	0	0	0
Clinch River:						
Clinton, Tenn	1	13	14	0	0	0
Kingston, Tenn	9	110	119	0	<1	<1
Colorado River:						
Loma, Colo	8	24	32	1	5	6
Page, Ariz	2	40	42	0	8	8
Boulder City, Nev	0	18	18	0	5	5
Parker Dam, Calif-Ariz	1	18	19	0	11	11
Yuma, Ariz	1	32	33	0	3	3
Columbia River:						
Northport, Wash	2	11	13	0	1	1
Wenatchee, Wash	1	12	13	0	1	1
Pasco, Wash	54	866	920	0	<1	<1
McNary Dam, Ore	26	381	407	0	1	1
Bonneville, Ore	16	315	331	0	1	1
Clatskanie, Ore	17	148	165	0	<1	<1
Connecticut River:						
Wilder, Vt	4	13	17	0	0	0
Northfield, Mass	9	10	19	0	0	0
Enfield Dam, Conn	3	13	16	0	0	0
Cumberland River:						
Clarksville, Tenn	7	31	38	1	4	5
Cuyahoga River:						
Cleveland, Ohio	1	31	32	0	0	0
Delaware River:						
Martins Creek, Pa	8	10	18	0	0	0
Trenton, N. J	5	10	15	0	0	0
Philadelphia, Pa	7	12	19	0	0	0
Escambia River:						
Century, Fla	4	16	20	0	0	0
Great Lakes:						
Duluth, Minn	2	3	5	0	0	0
Sault Ste. Marie, Mich	1	6	7	0	0	0
Milwaukee, Wisc	0	6	6	0	0	0
Gary, Ind	0	8	8	0	0	0
Port Huron, Mich	2	9	11	0	0	0
Detroit, Mich	1	7	8	0	0	0
Buffalo, New York	12	21	33	0	0	0
Green River:						
Dutch John, Utah	2	25	27	0	1	1
Hudson River:						
Poughkeepsie, N. Y	1	16	17	0	0	0
Illinois River:						
Peoria, Ill	10	17	27	1	0	1
Grafton, Ill	51	22	73	9	2	11
Kanawha River: Winfield Dam, W. Va	4	8	12	0	1	1
Kansas River:						
De Soto, Kansas	9	40	49	1	2	3
Klamath River:						
Keno, Oreg	5	13	18	0	0	0
Little Miami River:						
Cincinnati, Ohio	3	10	13	0	1	1
Maumee River:						
Toledo, Ohio	4	21	25	0	1	1
Merrimack River:						
Lowell, Mass	3	15	18	0	0	0
Mississippi River:						
St. Paul, Minn	2	23	25	0	2	2
Dubuque, Iowa	3	18	21	0	0	0
Burlington, Iowa	5	18	23	0	1	1
E. St. Louis, Ill	5	23	28	0	1	1
Cape Girardeau, Mo	4	26	30	0	3	3
W. Memphis, Ark	6	17	23	0	1	1
Vicksburg, Miss	16	17	33	3	1	4
Delta, La	9	21	30	0	1	1
New Orleans, La	0	21	21	0	1	1
Missouri River:						
Williston, N. Dak	16	19	35	2	3	5
Bismarck, N. Dak	2	24	26	0	3	3
Yankton, S. Dak	7	23	30	1	3	4
Omaha, Nebr	2	25	27	0	6	6
St. Joseph, Mo	3	20	23	1	4	5
Kansas City, Kans	11	34	45	1	7	8
Missouri City, Mo	12	25	37	3	5	8
St. Louis, Mo	7	28	35	0	5	5
Monongahela River:						
Pittsburgh, Pa	1	15	16	0	0	0
North Platte River:						
Henry, Nebr	7	42	49	1	28	29
Ohio River:						
Toronto, Ohio	2	12	14	0	0	0
Addison, Ohio	2	13	15	0	1	1
Huntington, W. Va	4	14	18	0	0	0
Cincinnati, Ohio	3	15	18	0	0	0
Louisville, Ky	1	20	21	0	1	1
Evansville, Ind	1	13	14	0	1	1
Cairo, Ill	4	13	17	1	1	2
Ouachita River:						
Bastrop, La	9	18	27	1	1	2
Pend Oreille River:						
Albeni Falls Dam, Idaho	2	7	9	0	1	1
Platte River:						
Plattsmouth, Nebr	11	27	38	1	6	7
Potomac River:						
Williamsport, Md	5	10	15	0	0	0
Great Falls, Md	6	13	19	0	0	0
Washington, D.C	5	12	17	<1	0	<1
Rainy River:						
Baudette, Minn	7	25	32	0	0	0
International Falls, Minn	6	30	36	0	0	0
Raritan River:						
Perth Amboy, New Jersey (5-ft. Below Surface)	7	15	22	0	4	4
Perth Amboy, New Jersey (5-ft. Above Bottom)	3	13	16	0	5	5
Red River, North:						
Grand Forks, N. Dak	2	58	60	0	2	2
Red River, South:						
Denison, Tex	1	37	38	0	0	0
Index, Ark	1	28	29	0	0	0
Bossier City, La	5	24	29	1	4	5
Alexandria, La	7	35	42	0	3	3
Rio Grande River:						
Alamosa, Colo	2	11	13	0	1	1
El Paso, Tex	3	19	22	0	2	2
Laredo, Tex	13	15	28	1	6	7
Brownsville, Tex	7	31	38	1	4	5
Roanoke River:						
John H. Kerr Resr/Dam, Va	3	9	12	0	0	0
Sabine River:						
Ruliff, Tex	11	21	32	1	1	2
Sacramento River:						
Courtland, Calif	4	6	10	0	0	0
St. Lawrence River:						
Massena, N. Y	9	23	32	1	8	9
San Joaquin River:						
Vernalis, Calif	2	13	15	0	1	1
San Juan River:						
Shiprock, N. Mex	5	16	21	0	2	2
Savannah River:						
North Augusta, S. C	4	12	16	0	0	0
Port Wentworth, Ga	5	14	19	0	0	0
Schuylkill River:						
Philadelphia, Pa	4	11	15	0	0	0
Shenandoah River:						
Berryville, Va	1	8	9	0	1	1
Ship Creek:						
Anchorage, Alaska	1	2	3	0	0	0
Snake River:						
Ice Harbor Dam, Wash	1	12	13	0	3	3
Wawawai, Wash	5	9	14	0	3	3
Payette, Idaho	4	13	17	0	5	5
South Platte River:						
Julesburg, Colo	18	84	102	2	42	44
Spokane River:						
Post Falls, Idaho	0	6	6	0	0	0
Susquehanna River:						
Sayre, Pa	12	7	19	1	0	1
Conowingo, Md	5	12	17	0	0	0
Tennessee River:						
Lenoir City, Tenn	5	7	12	0	0	0
Chattanooga, Tenn	1	18	19	0	<1	<1
Bridgeport, Ala	1	16	17	0	0	0
Pickwick Landing, Tenn	3	11	14	0	0	0
Tombigbee River:						
Columbus, Miss	13	15	28	1	0	1
Truckee River:						
Farad, Calif	4	9	13	0	0	0
Verdigris River:						
Nowata, Okla	2	30	32	0	2	2
Wabash River:						
New Harmony, Ind	4	17	21	0	0	0
Willamette River:						
Portland, Oreg	0	2	2	0	0	0
Yakima River:						
Richland, Wash	2	6	8	1	1	2
Yellowstone River:						
Sidney, Mont	6	44	50	0	9	8
Maximum	54	866	920	9	51	52
Minimum	0	2	2	0	0	0

Note: These data are preliminary; reanalysis of some samples may be made and additional analysis not completed at the time of the report may become available. For final data, one should consult the network's Annual Compilation of Data (6).

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to 51 pc/liter. Of all stations, four on different rivers had monthly average dissolved alpha activity between 10 and 51 pc/liter.

While there are no generally applicable standards for surface water, the radioactivity associated with dissolved solids provides a rough indication of the levels which could occur in treated water, since nearly all suspended matter is removed by the treatment process (*12*). The Public Health Service Drinking Water Standards state that in the absence of strontium-90 and alpha emitters,[1] a water supply is acceptable when the gross beta concentration does not exceed 1000 pc/liter (*13*).

REFERENCES

(*1*) Division of Water Supply and Pollution Control, Public Health Service: *National Water Quality Network Annual Compilation of Data, PHS Publication No. 663*, 1958 Edition, Superintendent of Documents, U. S. Government Printing Office, Washington, D. C. 20402. Price $1.50.

(*2*) *Ibid.*, 1959 Edition. Price $1.75.

(*3*) *Ibid.*, 1960 Edition.[2]

(*4*) *Ibid.*, 1961 Edition.[2]

(*5*) *Ibid.*, 1962 Edition.[2]

(*6*) *Ibid.*, 1963 Edition (in press).

(*7*) *Ibid.*, 1964 Edition (to be published).

(*8*) American Public Health Association, American Water Works Association and Water Pollution Control Federation: *Standard Methods for the Examination of Water and Wastewater*, 11th Edition, New York (1960).

(*9*) Harley, J. H.: Radiochemical Determination of Strontium-90, *Health and Safety Laboratory Manual of Standard Procedures*, August 1962 Revision, Radiochemistry and Environmental Studies Division, U. S. Atomic Energy Commission, New York Operations Office (1962).

(*10*) Public Health Service: National Water Quality Network, July 1963, *Radiological Health Data, 5*: 31-35, (January 1964).

(*11*) Weaver, L., A. W. Hoadley, and S. Baker: Radioactivity in Surface Waters of the United States, 1957-1962, *Radiological Health Data, 4*: 306-16, (June 1963).

(*12*) Straub, C. P.: Significance of Radioactivity Data, *Journal of the American Water Works Association 53*: 704 (June 1961).

(*13*) Public Health Service: *Drinking Water Standards, Revised 1962, Public Health Service Publication No. 956*, Superintendent of Documents, Government Printing Office, Washington, D.C. 20402 (March 1963), price 30 cents.

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[1] Absence is taken here to mean a negligibly small fraction of the specific limits of 3 pc/liter and 10 pc/liter for unidentified alpha emitters and strontium-90, respectively.

[2] Single free copies of this publication may be obtained from: Public Inquiries Branch, Public Health Service, U. S. Department of Health, Education, and Welfare, Washington, D. C. 20201.

RADIOACTIVITY IN MINNESOTA SURFACE WATER SUPPLIES,[1] JULY-DECEMBER 1963

Division of Environmental Sanitation,
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity concentration was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 71 stations have been sampled, but 7 surface streams and lakes involving 9 stations are now sampled routinely (see figure 1). "Grab" samples of raw and treated water are collected weekly at each station. No raw water is collected from the Minneapolis supply.

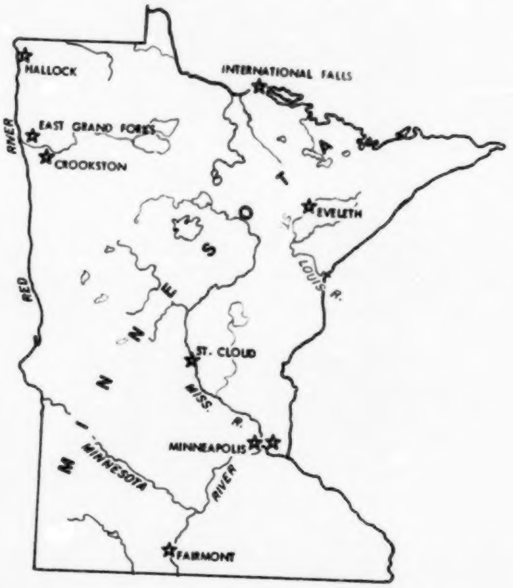

FIGURE 1.—SURFACE WATER SAMPLING LOCATIONS

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[1] Data and information from "Survey of Environmental Radioactivity, October-December 1963, State of Minnesota Department of Public Health. University Campus, Minneapolis 14, Minnesota 55440.

The samples are forwarded to the Division's Laboratory where they are analyzed for gross beta activity. A 500-ml sample of water is evaporated at 75° C from a planchet. The solid residue (suspended plus dissolved solids) is fixed by adding lucite in acetone. Afterwards, this sample is counted with an internal proportional counter. Counter standardization is accomplished by adding known amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows the monthly average gross beta activity in Minnesota surface water from July-December 1963. The minimum detectable level is a convenient low value not normally exceeded by one standard deviation; this is 15 pc/liter at present. In averaging, the value 7 pc/liter is used for samples having less than the minimum detectable value.

The data obtained on gross beta activity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variation in precipitation and flow rates of streams could contribute to this variation. Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from <15 to 118 pc/liter. Treated water in most cases contained less beta activity than the corresponding raw water.

Previous coverage in *Radiological Health Data:*

Period	Issue
October 1957-August 1959	*April 1960*
August 1959-April 1962	*August 1962*
April 1962-November 1962	*April 1963*
December 1962-June 1963	*November 1963*

TABLE 1.—TOTAL BETA CONCENTRATION IN MINNESOTA RAW AND TREATED WATER FROM SURFACE SUPPLIES, JULY-DECEMBER 1963

[Monthly average concentrations in pc/liter]

Town and water source	Type of water	July	August	September	October	November	December
Crookston, Red Lake River	Raw	[a]—	60	21	28	28	20
	Treated	—	47	21	25	15	<15
East Grand Forks, Red Lake River	Raw	118	64	46	21	32	22
	Treated	40	35	15	<15	30	<15
Eveleth, St. Mary's Lake	Raw	56	67	47	31	39	22
	Treated	49	52	45	23	34	24
Fairmount, Budd Lake	Raw	36	59	40	32	39	45
	Treated	55	22	31	<15	33	15
Hallock, Two Rivers South Fork	Raw	86	77	78	59	57	38
	Treated	51	38	37	40	51	<15
International Falls, Rainy River	Raw	89	—	40	<15	—	27
	Treated	62	—	17	<15	—	<15
Minneapolis Tap Water	Raw	—	—	—	—	—	—
	Treated	48	23	<15	<15	26	<15
St. Cloud, Mississippi River	Raw	—	42	—	<15	—	<15
	Treated	—	48	—	<15	—	<15
St. Paul, Vadnais Chain of Lakes	Raw	47	64	29	32	28	21
	Treated	36	28	<15	<15	21	<15

[a] Dash indicates no sample.

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Section IV—Other Data

ENVIRONMENTAL LEVELS OF RADIOACTIVITY AT ATOMIC ENERGY COMMISSION INSTALLATIONS

The U. S. Atomic Energy Commission receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant perimeter surveys are required.

Summaries of the environmental radioactivity data for 23 AEC contractor installations have appeared periodically in *RHD* since November 1960. Following are reports for Knolls Atomic Power Laboratory (KAPL) and the S1C Prototype Reactor Facility, summarizing the results for the 18-month period July 1962-December 1963.

Releases of radioactive materials from these plants for the periods covered in the reports below may be compared with standards set forth in the Federal Register, Title 10, Part 20. The appropriate concentration standards are given in table 1.

TABLE 1.—CONCENTRATION STANDARDS PERTAINING TO ENVIRONMENTAL MONITORING AT KAPL AND S1C [a]

Radionuclide	Air (pc/m^3)	Water (pc/liter)
Total activity in air if α emitters and Sr^{90}, I^{129}, Pb^{210}, Ac^{227}, Ra^{228}, Pa^{230}, Pu^{241}, and Bk^{249} are not present [b]	100	
Total activity in water if Sr^{90}, I^{129}, Pb^{210}, Po^{210}, At^{211}, Ra^{223}, Ra^{224}, Ra^{226}, Ac^{227}, Ra^{228}, Th^{230}, Pa^{231}, Th^{232}, and Th-nat are not present [b]	—	3,000
Mn^{54}-Co^{58}	1,000	90,000
Fe^{59}	2,000	50,000
Co^{60}	300	30,000
Sr^{89}	1,000	10,000
Sr^{90}	10	100
Cs^{137}	500	20,000
Ce^{144}-Pr^{144}	300	10,000

[a] The concentration standards given here were taken from the Atomic Energy Commission's regulation 10CFR, Part 20 (Federal Register, November 17, 1960).

[b] "Not present" implies that the concentration of the nuclide is small compared with its appropriate MPC. According to Federal Register, Title 10, Part 20, August 9, 1961, a group of nuclides may be considered not present if the ratio of each nuclide to its appropriate MPC is equal to or less than 1/10 and if the sum of these ratios for the group in question is equal to or less than ¼.

1. Knolls Atomic Power Laboratory, July 1962-December 1963

General Electric Company,
Schenectady, New York

The principal function of the Knolls Atomic Power Laboratory (KAPL), operated by the General Electric Company for the Atomic Energy Commission, is to support the Naval Reactors Program of the Commission in the development of atomic power reactors for naval propulsion. This includes design, construction and prototype operation of nuclear power reactors.

The Knolls Atomic Power Laboratory consists of two sites, the Knolls site and the West Milton site, located as shown in figure 1. The Knolls site occupies approximately 170 acres upon which are located administrative buildings; chemistry, physics, metallurgical, engineering and radioactive materials laboratories; critical assembly buildings; machine shops; decontamination facilities; radioactive waste storage and processing facilities; and nuclear fuel storage and assembly buildings. The West Milton site occupies approximately 4,000 acres. Its principal facilities include the Triton (S3G) and Bainbridge (D1G) prototype reactors, equipment service building, fuel service building and waste treatment facility.

Air Monitoring

Environmental airborne radioactivity is measured at three locations on the Knolls site, four locations on the West Milton site and at the General Electric Company Research Laboratory, approximately one mile west of the Knolls site. Airborne radioactivity is sampled continuously and analyzed on a weekly basis.

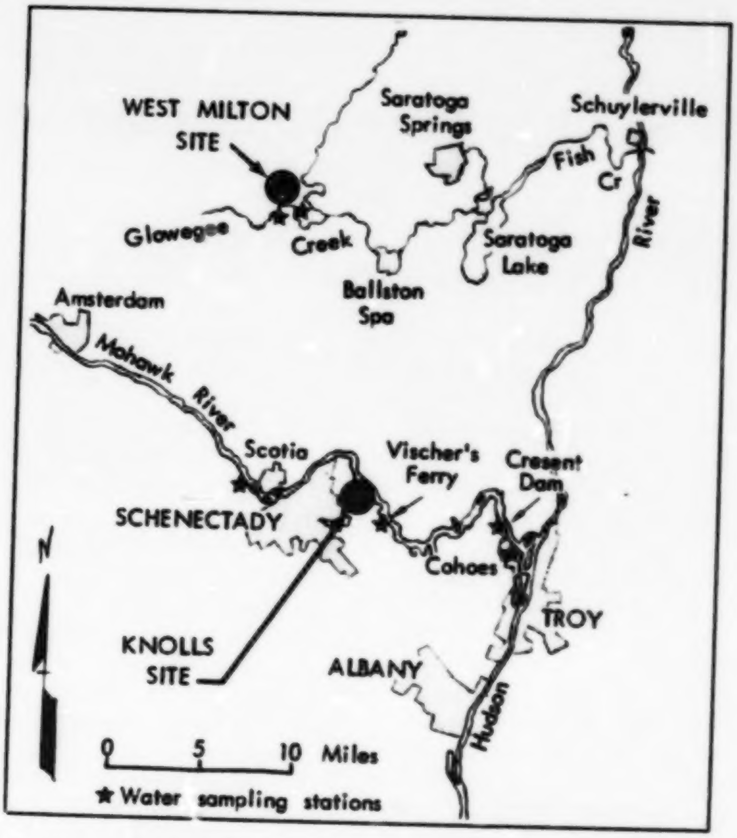
WEST MILTON SITE
Saratoga Springs
Schuylerville
Fish Cr
Glowegee Creek
Saratoga Lake
Ballston Spa
River
Amsterdam
Mohawk River
Scotia
Vischer's Ferry
Cresent Dam
SCHENECTADY
N
Cohoes
TROY
KNOLLS SITE
ALBANY
Hudson
0 5 10 Miles
★ Water sampling stations

FIGURE 1.—ENVIRONMENTAL MONITORING LOCATIONS, KAPL

The results of the airborne radioactivity analyses are given in table 2. Measurements of airborne radioactivity are made at least 48 hours after collection allowing the naturally occurring short-lived materials to decay.

TABLE 2.—AIRBORNE BETA ACTIVITY, KAPL

[Average concentrations in pc/m³]

Sampling locations	Second half 1962	First half 1963	Second half 1963
Knolls site	4.03	6.18	2.93
West Milton site	5.49	9.20	2.97
Off-site	3.95	6.37	2.59

Liquid Waste Monitoring

The dilution potential of the Mohawk River is utilized to a limited degree in the disposal of liquid radioactive wastes from the Knolls site. All potential sources of liquid radioactive waste at the Knolls site are connected by control drains to collection tanks in the radioactive waste processing building. The release of liquid waste to the Mohawk River is regulated according to the concentration of fission products in the collection tanks and the flow of the river. A continuous proportional sample of the Knolls Site combined sewer effluent is taken at the point of discharge to the Mohawk River. Radiochemical analyses of weekly composite samples show that strontium-90 is the principle component to be considered in control. The amounts and the radioistopic content of the combined sewer effluent discharged from the Knolls site have been summarized in table 3. A total of

TABLE 3.—RADIONUCLIDE CONCENTRATIONS IN THE KNOLLS SITE WASTE EFFLUENT, KAPL

[Average concentrations in pc/liter]

Radionuclides	Second half 1962	First half 1963	Second half 1963
Sr^{89}	14,000	28,000	7,000
Sr^{90}	1,400	16,000	18,000
Cs^{137}	45,000	45,000	25,000
Ce^{144}-Pr^{144}	32,000	43,000	17,000
Gross beta	110,000	140,000	67,000

54.8 curies of beta activity was discharged to the Mohawk River during the 18-month period of this report.

Mohawk River water is sampled continuously at the General Electric Company powerhouse eight miles upstream from the Knolls site, and the Vischer Ferry powerhouse approximately two miles downstream. Samples taken from the Cohoes pumping station approximately thirteen miles downstream show very nearly the same average concentrations obtained for the Vischer Ferry samples shown in table 4.

TABLE 4.—GROSS BETA ACTIVITY IN STREAMS RECEIVING EFFLUENTS, KAPL

[Average concentrations in pc/liter]

Stream and location	Second half 1962	First half 1963	Second half 1963
Mohawk River (Knolls site):			
G.E. Powerhouse (upstream)	11	19	12
Vischer Ferry (downstream)	15	15	21
Glowegee Creek (West Milton site):			
Upstream	24	41	16
Downstream	27	30	18

Since the Glowegee Creek does not have a reliable dilution potential, the radioactivity levels in the liquid waste from the West Milton site are operationally controlled and diluted prior to release to the creek. A total of 0.017 curies was discharged at two points into Glowegee Creek during the 18-month period at monthly average concentrations ranging from 6 to 440 pc/liter.

Samples of the Glowegee Creek water are taken once a week at two locations, 150 feet above the point where the S3G effluent enters the stream, and the other 2,640 feet below the S3G discharge or 1500 feet below the D1G discharge.

Previous coverage in *Radiological Health Data:*

Period	Issue
1959 and first quarter 1960	*December 1960*
Second quarter 1960	*January 1961*
Third and fourth quarters 1960	*September 1961*
First and second quarters 1961	*March 1962*
July 1961-June 1962	*July 1963*

2. S1C Prototype Reactor Facility
July 1962-December 1963

Combustion Engineering, Inc.
Windsor, Connecticut

The S1C Prototype is a land based nuclear submarine power plant facility, operated for the Atomic Energy Commission by the Naval Reactors Division of Combustion Engineering, at Windsor, Connecticut. The Prototype contains a pressurized water reactor power plant which is used for research, development and training.

Essentially all of the radioactive wastes originate from activation of minute amounts of impurities and corrosion products in the circulating water used as a reactor coolant. Ventilation air from the submarine hull and the supporting facility is continuously monitored at the exhaust stack. Liquid wastes are monitored before discharge to the Farmington River. Tables 5 and 6 give the average beta concentrations of airborne and liquid wastes before release to the environment.

TABLE 5.—AIRBORNE BETA ACTIVITY, S1C

[Average concentrations in pc/m³]

Sampling location	Second half 1962	First half 1963	Second half 1963
Stack discharge	46	54	59
On-site downwind from stack	8.3	9.0	8.4
On-site average [1]	—	—	2.2
Off-site average [1]	—	—	3.0

[1] These samples were not collected until second half 1963.

TABLE 6.—RADIOACTIVITY IN LIQUID WASTES DISCHARGED INTO THE FARMINGTON RIVER, S1C

Activity	Second half 1962	First half 1963	Second half 1963
Total beta activity (curies)	0.020	0.021	0.010
Average gross beta concentrations (pc/liter):	4,300	4,900	2,000
Co^{60}	3,300	3,700	5,200
Fe^{59}	290	670	870
Mn^{54}-Co^{58}	1,300	950	1,900

Figure 2 shows the locations of six water sampling stations along the Farmington River and of 17 fallout monitoring stations. A more detailed description of S1C Prototype Reactor Facility and its control measures is available in the September 1961 issue of *Radiological Health Data*. Comparisons of the data for up-

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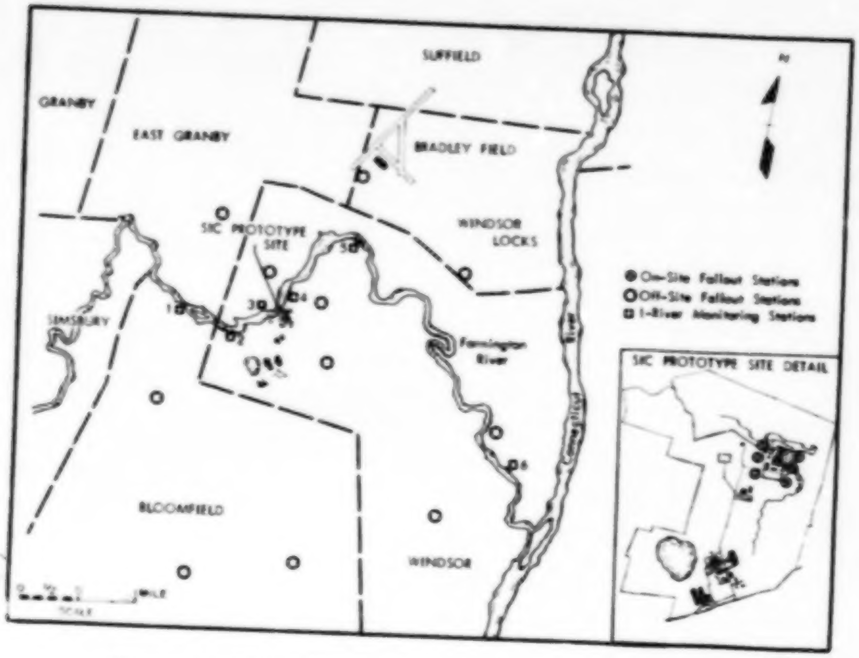
SUFFIELD
GRANBY
EAST GRANBY
BRADLEY FIELD
SIC PROTOTYPE SITE
WINDSOR LOCKS
SIMSBURY
Farmington River
Connecticut River
BLOOMFIELD
WINDSOR
N
● On-Site Fallout Stations
○ Off-Site Fallout Stations
◘ 1-River Monitoring Stations
SIC PROTOTYPE SITE DETAIL
SCALE
MILE

FIGURE 2.—ENVIRONMENTAL MONITORING LOCATIONS, SIC PROTOTYPE SITE

stream and downstream samples appear in table 7. Comparisons of on-site and off-site fallout samples appear in table 8.

TABLE 7.—BETA ACTIVITY IN THE FARMINGTON RIVER, SIC

[Average concentrations in pc/liter]

Sampling station numbers (See figure 2)	Second half 1962	First half 1963	Second half 1963
Upstream:			
1	18	30	160
2	14	—ᵃ	—
Outlet:			
3	14	12	99
Downstream:			
4	14	—	—
5	14	23	62
6	15	33	57

ᵃ Dash indicates sampling discontinued.

TABLE 8.—BETA ACTIVITY IN FALLOUT, SIC

[Average deposition in nc/m²/month]

Locations	Second half 1962	First half 1963	Second half 1963
On-site (6 stations)	44.65	61.37	ᵃ 26.55
Off-site (11 stations)	56.80	53.46	ᵃ 79.83

ᵃ These averages represent 29 on site samples and two off-site during the period July 1–24, 1963, after which fallout sampling was discontinued.

Previous coverage in *Radiological Health Data:*

Period	Issue
January-March 1960	*November 1960*
April-June 1960	*January 1961*
July-December 1960	*September 1961*
January-July 1961	*March 1962*
July 1961-June 1962	*July 1963*

REPORTED NUCLEAR DETONATIONS, MAY 1964

Two low-yield underground nuclear tests conducted during May 1964 at the Nevada Test Site were announced by the Atomic Energy Commission. (Low yield range is defined as equivalent to less than 20 kilotons of TNT.) Tests conducted on May 14 and May 15 were assigned arbitrary *Radiological Health Data* reference numbers 156 and 157, respectively.

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